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AUTHORITY AND RESPONSIBILITY

THE Reith Memorial Lectures which Lord Radcliffe delivered last autumn, published under the title "The Problem of Power"*, and Sir Ernest Barker's "Principles of Social and Political Theory"†, published last autumn, have more in common than a critical discussion of one of the central issues of our times. Both are concerned with the problem of power—with the reciprocal relations of government and citizen. Both face the question of authority and responsibility and its implications, which Lord Russell analysed under the title "Authority and the Individual" in the first series of Reith Lectures. Both probe commonly accepted theories and ideas and stimulate fresh thought as to their meaning and relevance to the situation in which we find ourselves to-day.

On such general grounds the man of science who takes up these two books, so different in scale, but so similar in their range of scholarship and perspicacity of thought, will find them sufficiently stimulating and rewarding. But there is a further reason why they deserve his attention; for they show that we are not appreciably nearer to a solution of the problem of knowledge and power, and of the place of the expert in the organization of government, than we were when General Smuts discussed that theme in his Sidgwick Memorial Lecture at Cambridge in November 1929 on democracy. We continue to be confronted repeatedly with instances of difficulties due to neglect to take account of physical facts or deliberate disregard of technical advice; and the same nonsense about the unsuitability of the scientific man for administrative responsibility, and the subordination of the technical man to the administrator, is put forth by responsible officials, blind to all the experience of industry during the past two or three decades.

Sir Ernest Barker does not, in his latest book, examine the place of the expert in government so closely as he did earlier in his "Reflections on Government". Nevertheless, both he and Lord Radcliffe throw fresh light on various aspects of the relations of the man of science to government and society, and may well stimulate the thinking that is required to solve problems such as those of loyalty and security, the place of the voluntary body in the modern State, and professional associations and their responsibilities. Particularly in Sir Ernest Barker's book, such specific questions are frankly faced, their implications are indicated, and although no particular solutions are suggested, at least some guidance is given as to the principles which must be recognized in seeking a solution, and of which full account must be taken.

One notable contribution of this type comes from Sir Ernest's examination of the relation between society and the State, and the place and functions of social groups. His analysis shows the weakness of

* The Problem of Power: the Reith Memorial Lectures, 1951. By the Rt. Hon. Lord Radcliffe of Werneth. Pp. xvi+110. (London: Martin Secker and Warburg, Ltd., 1952.) 8*s.* 6*d.* net.

† Principles of Social and Political Theory. By Sir Ernest Barker. Pp. 284. (Oxford: Clarendon Press; London: Oxford University Press, 1951.) 25*s.* net.

some of the arguments which have been advanced for functional parliaments of one type or another, but emphasizes the scope that exists for bodies formed by voluntary action for the expression of social aspirations and social opinions. These, however, he points out, are not social parliaments but rather parliaments of society and do not involve devo lution of central government. They would be without legislative powers, and Sir Ernest sees in them rather a fuller expression of social invention in terms of the conditions and temper of our times.

By clarifying the confused ideas and defects of logic that have marked some proposals for the functional devolution of the powers of the State, Sir Ernest contributes to clearer and more constructive thinking about both the problem of provincial or regional devolution and the relations between local and central government on one hand, and on the scope of voluntary bodies and their relations with the State on the other. While he challenges the idea that the State can or should devolve any part of its powers upon social groups, he believes that the modern State owes a large and generous measure of respect to such groups in the exercise of their own intrinsic and native powers. The State, he urges, should recognize frankly that there is a whole area of social action parallel to, if different from, its own area of legal action—an area of voluntary action, of tentative non-official effort, of many-sided initiative and manifold experiment. Accordingly, it can respect and protect the liberty and rights of groups, as well as the liberty and rights of individuals, and as part of such respect and protection, develop a general law of associations and their rights, side by side with its private law of persons and the rights of persons. Further, the State can give positive aid and encouragement to the activities of such groups and associations when they are doing good work for the benefit of the general community.

Sir Ernest Barker refers specifically to the University Grants Committee as an example both of such aid and encouragement and of the means by which assistance can be given, and although the value of the work of such voluntary bodies was emphasized by Lord Beveridge in his study of methods of social advance under the title "Voluntary Action" four years ago, Sir Ernest puts the work of such bodies or 'creative minorities' not so much in a wider perspective as in the context of the principles which should govern their evolution and their relations with the State. It is evident from recent reports from the Nuffield Foundation, the Carnegie Institution of Washington and from a recent article by Sir Hector Hetherington on "Trusts and Foundations in the new Social Order" that these problems are already engaging the minds of those responsible for the direction of the universities and other independent institutions, particularly in respect of their research activities, and that the ideas ventilated in an important debate on this subject in the House of Lords on June 22, 1949, are being explored, both in Great Britain and in the United States of America. Sir Ernest Barker's book will repay study by all who are concerned with such problems, and may well help the formulation of constructive proposals and stimulate the process of social invention.

No matter how fully professional associations explore such possibilities, the extent to which voluntary bodies can serve the community is determined by the same climate of opinion as determines the choice by government of what is administratively possible from what is technically possible. It could be argued that in his plea for the use of the scientific political expert or tribunal and of the scientific spirit in the task of government, General Smuts did not pay enough attention to this factor. Certainly the intervening years have emphasized the immensity of the task of education still to be undertaken before we can hope to see political action based firmly on the facts of a situation and not on prejudice.

Nor is this entirely a matter of the point in the organization of government at which scientific or technical advice is given. Sir Ernest Barker, from another angle, emphasizes a vital point which was virtually ignored by the late Prof. H. J. Laski when, in his "Reflections on the Constitution", he drew this important distinction between research which directly affects immediate policy and that which determines long-range policy. In the last annual report of the Carnegie Institution of Washington, Dr. Vannevar Bush was concerned lest intervention of the State to protect the unfortunate or underprivileged might have untoward effects on initiative and enterprise generally. Sir Ernest Barker also points to this danger, but his warning that in any such change there is a spiritual price as well as a material price to be paid, and that there is danger that losses may even offset the apparent material gains, is supported by reasoned argument, presented as cogently as were his observations in an earlier book on the conflict between the spirit of accommodation and discussion and the spirit of intransigence.

The wisdom and reasonableness displayed in this volume are badly needed to-day, when both major political parties at times seem less concerned with the national interest than with the promotion of faction, sectional interests or the very clash between individualism and collectivism, freedom and regulation which in concluding Sir Ernest denies and rebutts. The antithesis, he insists, is unreal; both the voluntary principle and legal control and regulation are needed. The real issue is not so much what the State should do and what society should do, as when and in what conjuncture society should be the agent, and when and in what conjuncture the agent should be the State. His conclusion is in favour of the maximum of voluntary self-help by groups of individuals, voluntarily acting for themselves in the social area; thinking out for themselves, in their own sphere of interest, the requirements and conditions of their own development; and, when they have thought them out for themselves, going on to achieve them by themselves, and by their own efforts, so far as in their own sphere they can.

It is the reasoned argument that is brought to support this point of view that gives such distinction to the book. Principles which can guide us in striking

the balance are made clear, and this is as true of such matters as professional freedom and loyalty as it is of voluntary action or the limitations which political parties must accept in a democratic State. Discussion, he reiterates, is the vital process of the life of any organized community, and those actions which abolish discussion destroy also the common life.

There could not well be a better corrective to some of the thinking and actions that in the past decade have so impoverished public life and threatened the integrity of our institutions, scientific and technical as well as others. These wise words on the importance of timing, and Sir Ernest's appreciation of the value of the voluntary agencies in respect of variety and spontaneity, are accompanied by full appreciation of the need for organized political parties in order that parliamentary government may function. He sets these, however, in the context of the society which the State should serve, and he invokes his principles of liberty, of equality—as distinct from uniformity—and of fraternity, not as isolated themes, but to be reconciled with each other and set in the context of a dynamic view of justice, joining and fitting together principles as well as persons. Here may well be found that stimulus to the creative thought about institutions which should help us to ask and to answer those vital questions about power and responsibility—the extent of the activities of the State, the reconciliation of State activity with enterprise and initiative, the desirable extent of equality of income, property or opportunity and the means for achieving them with least detriment to spiritual values—to which Lord Radcliffe also directs us. Above all, it should set us to that task of the general understanding and revaluation of character, ideas and institutions, as well as of thinking, which alone can avert the greatest danger to which Lord Radcliffe points, namely, the danger of losing our character, which is often superb, and being left with our institutions, which are sometimes inept. At the least, both Sir Ernest Barker and Lord Radcliffe make manifest the richness and greatness of our heritage and the relevance to our present problems of the aphorisms of Mill, Bagehot, Matthew Arnold and many others.

MATHEMATICAL SOCIOLOGY?

Mathematical Biology of Social Behavior

By Nicolas Rashevsky. Pp. xii+256. (Chicago: University of Chicago Press; London: Cambridge University Press, 1951.) 37*s.* 6*d.* net.

IT is claimed on the dust jacket of this book that "[it] comes as a challenge to quantitative social science. In great part the quantitative work of the social scientists has been of a purely empirical nature: measurable quantities were measured, and their quantitative relations described. While this approach unquestionably aids our knowledge of social facts, it does not provide a way to discover which relations are expressive of deeper realities and which are merely incidental. Professor Rashevsky proceeds otherwise. He starts with postulates concerning the behaviour and interaction of individuals among themselves and with their environment. . . . The 'large' social phenomena (emergence of classes, urbanization, social change, revolution) then emerge as *derived* mathematical formulations. . . . Hence a new dimension is added to social research".

Prof. N. Rashevsky, who holds the chair of mathematical biology in the University of Chicago, has written extensively on mathematical biophysics and is the author of a mathematical theory explaining mathematically certain physiological phenomena of the central nervous system. I am not competent to judge the value and significance of that work; but Prof. Rashevsky evidently believes that his discoveries in that field have an important bearing on the social sciences. The present volume therefore starts with a summary of some of his results and proceeds in a series of chapters to consider some of the "'large' social phenomena". The general procedure is to lay down certain postulates about human behaviour or about the association between certain variables, and then to draw conclusions from these postulates using mathematical methods of argument.

It is difficult to see what is gained by this approach. Prof. Rashevsky almost appears to believe that the use of mathematical methods in argument is an end in itself, for in his foreword he pleads as a point in his own favour that "the author actually uses mathematics everywhere, and does not merely talk about using it". Now it need scarcely be said that, in certain circumstances, mathematics may be helpful in making argument exact and in being conducive to clarity of thought. But if the results of mathematical manipulations claim to be of use in the explanation of phenomena observed in the real world, they should be verifiable empirically. It is not enough to claim that certain relations could be verified *in principle*, as is done on several occasions in this book, particularly as the problem of measurement in the social sciences presents serious difficulties of its own.

Two results may be quoted in illustration. On p. 69 it is stated "that if the distribution of any innate ability which may affect social status is uniform, the social status will be distributed non-uniformly, as long as either one or both of the following conditions hold: the social status affects the probability of social encounters, or the probability of an individual's travelling a certain social distance is a function of that distance". This appears to assume in the first instance that social status is in some way influenced by innate ability, an assumption which is not immediately obvious and which in many societies may well be false. Moreover, social status itself is not defined; it is merely stated that the units measuring it will be chosen so that the measure lies within a certain interval. Social distance is apparently the difference between two social statuses and seems by implication to be treated as a continuous variable. Nowhere does Prof. Rashevsky consider whether it is really possible to regard social status as a uni-dimensional variable—that appears to be regarded as self-evident; nor does he show any signs of being aware of the difficulties that have been encountered in attempting to make this term more precise. His conclusion, which undoubtedly is a logical consequence of his assumptions, is quite unverifiable, and his assumptions are far from being universally true.

Again, we read on p. 231 that "if in any country the inequality $U(\bar{x},a,\beta,\varphi_0) > H$ becomes satisfied and if the condition of political restrictions is satisfied, then a revolution will occur and will not be prevented

by jailing either eleven or eleven hundred communists". Three of the parameters entering into the inequality are what Rashevsky calls "psychobiological" ones; and although he claims that their averages and distribution function can *in principle* be determined experimentally, he does not enlarge on this statement, which seems to be unfounded. Thus φ_0 is a threshold above which an individual will be willing to apply force to improve his social conditions. It is not clear how the average value of this threshold can be obtained, nor even in what units it is measured. For all its air of mathematical precision, when the conclusion is shorn of its mathematical trappings it seems to mean that, if in a society there are sufficiently many people who are willing to apply a sufficient degree of force to improve their social conditions, a revolution will occur. In this form, the conclusion is not very profound and scarcely novel.

I do not think it is unfair to quote these two examples as representative, and I believe that, even though some of the results are not inherently unreasonable, the usefulness of the mathematical treatment is strictly limited. Social theorists who wish to explain what Prof. Rashevsky calls the "'large' social phenomena" can attempt to do so without the elaborate mathematical apparatus adduced here. Empirical sociologists, on the other hand, will at present have to content themselves with measuring what is measurable, thus adding slowly and laboriously to our still woefully inadequate knowledge of social facts, and in trying to improve their techniques of measurement. This may be rather pedestrian in comparison with an explanation of the "deeper realities", but is likely to be more fruitful in the long run.

E. Grebenik

TREATISE ON INDUSTRIAL CHEMISTRY

Traité de chimie industrielle

Par Paul Baud. Quatrième édition, revue et complétée. Tome 1: Grande industrie chimique; problème de l'eau. Pp. ix+865. 5000 francs. Tome 2: Métalloides et métaux. Pp. vii+1053. 5800 francs. Tome 3: Industries organiques. Pp. vii+1148. 6800 francs. (Paris: Masson et Cie., 1951.)

M. PAUL BAUD has undertaken a stupendous task in writing, apparently unaided by any collaboration, these three volumes—a task to be measured not solely by the number of pages of closely printed matter but also by the highly diversified nature of the contents.

In Vol. 1 the production of common salt, the mineral acids, ammonia and other products based on nitrogen, the alkalis, fertilizers—natural and synthetic—receive very full treatment, and this volume closes with a chapter on water, its treatment for industrial uses and the production of potable water. Attention is focused on the many sources of contamination which can affect river water through trade effluents. The menace of river pollution is now well appreciated in most countries of western Europe and the United States because of its bearing on the problem of ensuring pure water supplies for drinking purposes.

About half this volume is taken up by consideration of solid fuels—wood, torbanite, lignite and coal, and their various distillation products. Low-temperature carbonization of coal and similar materials, the hydrogenation of coal—here some account is given of the Imperial Chemical Industries process at Billingham—and the high-temperature carbonization of coal for the production of coke and gas are well described, as likewise the German processes for utilizing brown coal, and shale retorting as practised in Scotland, Estonia and France.

The petroleum industry is considered very fully, attention being directed to the geology and distribution of the oil-bearing strata, the character of the different classes of natural petroleum now being won, followed by an account of the treatment of the crude oil and the various methods of refining adapted to the composition and character of the oil produced in various parts of the world. Adsorption, thermal cracking and its rationale, with a brief description of the principal methods of cracking employed and the products resulting therefrom, receive adequate, if not always very full, treatment. Modern methods of refining are outlined, although, in describing the solvent method of treating wax-base oils, there is no mention of the use of furfural, now well established in the United States and Great Britain. Much attention has been paid to describing the Fischer-Tropsch and similar processes. This section of the book gives a full account of recent work on polymerization, dehydrogenation, isomerization and alkylation, all of importance in the development of any chemical industry having as its raw material hydrocarbons of the petroleum industry. Petrol, kerosene, white oil, paraffin wax, petroleum jelly, asphalt and pitch are described with full attention to properties and uses.

Vol. 2 embraces in its scope hydrogen, the halogens, the liquefaction of gases; oxygen, sulphur, phosphorus and their compounds; and industries based on silicon and carbon. In the part devoted to metals, the metallurgy of iron and steel is the longest and fullest section in the whole work and is well done, and particular note is made of the many types of high-duty steel alloys. But less space is devoted to a consideration of precious metals, the rare-earth metals and radioactive elements. Throughout this volume not much space is afforded to description of the salts of the various metals.

As is inevitable in a work of such scope, some chapters are far too brief and sketchy. The French have long been pre-eminent in the manufacture of fine soaps and perfumes, and it might have been expected that these two industries would have merited more detailed treatment in Vol. 3 than has been accorded them. But the chapters dealing with the industries based on cellulose, starch and sugar are well done, as likewise those on ethyl alcohol and on the fats and waxes. Dyestuffs, plastics and the rubber industries—natural and synthetic—and pharmaceuticals receive adequate treatment. But in the account of penicillin, no mention is made of the pioneering work of Fleming—a surprising omission.

As this is a work on industrial chemistry, its value would be enhanced by including in the appropriate places some up-to-date statistics showing production of raw materials and chemical products of world-wide importance. For example, it would be of great value to have some indication of present-day production of coal, coke, petroleum, the principal fatty oils and oil seeds, rubber and rosin, together with statistics showing world production of iron ore, steel, the principal metals and such important basic chemicals as common salt, natural and synthetic nitrates, caustic soda and sulphuric acid. The theoretical

considerations underlying manufacturing processes are generally well treated, due attention being paid to physicochemical, thermochemical and thermodynamic relations—in many instances ably illustrated by appropriate diagrams.

There is much in these important volumes that the reviewer has not examined in detail, but even a cursory glance would reveal one outstanding defect—and it is indeed a serious one—a complete absence of documentation: there is not even a brief bibliography at the end of any chapter. Throughout these three thousand pages, though the names of investigators and of those prominent in chemical research and technology are mentioned in their appropriate places and with dates in many instances, chapter by chapter, nowhere is there a reference to any of their published papers or patents. It is hoped that the author may remedy this defect in any future edition. The addition of an author index would also be welcome: it might serve, during its compilation, to ensure more care in the spelling of proper names: some place names and authors' names, notably British and some American ones, are mis-spelled.

The volumes are copiously illustrated by nearly six hundred clear line-drawings, amply and carefully lettered, which greatly facilitate the reading of the text. It is a pleasure to record how well the volumes are printed and bound; despite the fact that the price to British readers will seem very high, the amount of matter available is of great value, though there is little information about developments of date later than 1947. H. M. LANGTON

EMBRYOLOGY AND EVOLUTION

Embryos and Ancestors

By G. R. de Beer. (Monographs on Animal Biology.) Revised edition. Pp. xii+160. (Oxford: Clarendon Press; London: Oxford University Press, 1951.) 15*s*. net.

OTHER than standard texts, there are few biological books that have enjoyed so long and fruitful a life as Dr. G. R. de Beer's "Embryos and Ancestors". It first appeared in 1930 under the title of "Embryology and Evolution", and ten years later, in expanded form, under its new title. The present volume is thus the third embellishment of Dr. de Beer's theme—that variation in the order and rate of appearance of structures in successive ontogenies (heterochrony) can have a considerable influence on phylogeny. Some new passages have been added to the original fifteen chapters of the book, and a smaller number of old ones deleted. There are four new chapters, of which the first three (on the evolution of the cœlenterates, on embryology and taxonomy, and on embryology and homology) are based on articles which Dr. de Beer has already published. The fourth, on the germ layers, is new.

Dr. de Beer cautions his reader that "it is characteristic of a slogan that it tends to be accepted uncritically and to die hard". Hence, he writes, schoolboys still incorrectly learn that during its life-history an animal "climbs up its family tree". His argument with the recapitulationists is, however, on a narrow issue; and, in his view, there would be no reason to disagree with them if only they "would abandon the assertion that that which is repeated is always the adult condition". Aware, therefore, that small matters can become the cause of much misunderstanding, he points out in his preface that, when he writes that pædomorphosis (by which he means the appearance or retention, in the adult stage of the ontogeny of a 'descendant', of a structure characteristic of the young stage of an ancestral animal) "has resulted in this, that, or the other", he is merely saving time and space—and not implying the operation of some peculiar process. Schoolboys and their masters do not, however, always read prefaces. There is, therefore, a danger that the view that major evolutionary changes are due to the operation of something called pædomorphosis, a thesis which Dr. de Beer expounds, may, in spite of his warning, also become a new slogan.

Nevertheless, this book will continue to serve the very useful purpose of introducing the student to an argument that not only has a long history but also practically a vocabulary of its own. Dr. de Beer writes with imagination, and what he provides launches the reader into an interesting and exciting field of biological thought. S. ZUCKERMAN

ANALYSIS BY DIFFUSION

Microdiffusion Analysis and Volumetric Error

By Prof. Edward J. Conway. Third revised edition. Pp. xxiv+391. (London: Crosby Lockwood and Son, Ltd., 1950.) 25*s*. net.

CONWAY'S influence on analytical chemistry has been twofold; it is a matter of temperament which one considers the more important. To some, in whose breasts the craft spirit still flutters, Conway's applications of his own elegant concept of microtitration in the Conway unit with the Conway burette are a permanent source of pleasure, whether in using or even in just contemplating them. The methods of micro-diffusion analysis have had, and are still having, a widening application; the main, if not the only, limitation to their usefulness is that the analysand must take part in the production of a diffusible compound that can be absorbed by a reagent in a closed system and that the change resulting from this absorption can be accurately measured. Examples of reactive substances measured in the Conway diffusion unit are ammonia, from Kjeldahl digestion or urea hydrolysis, alcohol in blood, carbon dioxide from sugar fermentation or carbonates and bicarbonates in body fluids, and a number of other substances not easily to be separated or isolated in small amounts with the precision required especially in biochemical analysis.

This third edition of what has now become an essential part of most analysts' libraries includes a number of new applications, for estimating carbon monoxide, lactic, acetic or other volatile fatty acids and chloroform in blood, as well as a modification of Winnick's method for alcohol in blood.

In spite of the combined æsthetic and practical appeals of the method, it has still not replaced all others for certain analyses in which its advantages seem overwhelming. Thus its use for routine estimations of urea, especially in places where potent vegetable sources of urease are easily available, make all other procedures deserve to become obsolete: it is at least as precise and as accurate as the best of them and is much less demanding of labour, that is, of time and attention. Yet only recently a biochemical journal published still another version of a micro-

method, involving distillation after alkaline hydrolysis: the author probably never even considered, let alone tried out, the micro-diffusion technique.

It is in the science rather than in the art of volumetric analysis that Conway has made his other outstanding contribution to the practice of analytical chemistry, namely, in the study of error in volumetric titration, to which the book owes the second part of its title. It is the subject of some 115 pages—nearly one-third of the whole. In the opening eight chapters of the book there are 85 pages devoted to a discussion of the apparatus and principles used in micro-diffusion analysis; there also the author has much of value to say on various sources of error that still may go unrecognized.

Discussions of methodology thus occupy a large share of Conway's book—large, anyhow, relative to the space that analysts would have thought appropriate, say, twenty-five years ago. The influence of Conway on almost every branch of analytical chemistry is a tribute to the fundamental importance of—and the unseverable connexion between—his theory and practice; there are few authors that can have produced such wide effects with so few words in so short a time. The book's 376 pages (excluding references and index) appear modest indeed when compared with the great tomes (at correspondingly great prices) under which the scientist's shelves to-day increasingly groan. Maybe this is in part because the book first appeared only thirteen years ago and has not yet had time to swell unduly. More likely, it seems to me, it is an expression of the rare combination of modesty, logicality and singleness of purpose that caused the author originally to say no more and no less than was absolutely necessary, and to stick to that admirable procedure in both subsequent editions.

The production, printing, paper and binding of the book, its freedom from errors, the clarity of illustrations and graphs, all show an anxiety on the publisher's part to co-operate in the continued success of one of the outstanding scientific monographs of our day.

A. L. Bacharach

FACTS AND SPECULATIONS ABOUT PROTEINS

Chemistry and Biology of Proteins

By Prof. Felix Haurowitz. Pp. xii+374. (New York: Academic Press, Inc., 1950.) 5.50 dollars.

THE appearance of a new text-book dealing with proteins is bound to be an occasion of great interest to students, teachers and research workers. Each previous effort to deal with this large field has been unsatisfactory in one respect or several, although, taken together, the existing text-books gave a useful synopsis of the literature down to about 1940. Prof. F. Haurowitz's book was written with graduate students in mind. Such students require from a text-book a connected account of a subject, with key references to monographs and reviews. This they will find. For specialists, too, there is a real mine of references here that will be useful to them, even if they can expect nothing of a comprehensive nature; and there are not many serious errors of substance.

Prof. Haurowitz shows, as those who have followed his experimental work will expect, a real feeling for the obligate relationship of the physical and chemical properties of proteins with their biological functions; the plan of the book reflects this feeling in an original way. After a short section on practical methods for extracting and handling proteins, the evidence is set forth on which modern ideas on the structure of proteins are based. Here an enormous amount of painstaking work by organic chemists is treated very cursorily; there is no reference to the discovery and structural elucidation of the amino-acids, nor to the synthesis and natural occurrence of peptides. On the other hand, much of the physical chemistry is given at considerable length. This is a pity, because previous text-books have shown a similar bias. This factual material is then reconsidered in a discussion on internal structure of globular proteins. The occurrence, properties and biological functions of the various proteins are then surveyed under the following heads: albumins, globulins and other soluble proteins; insoluble proteins (scleroproteins); conjugated proteins; proteins with enzymatic properties; proteins with hormone activity; role of proteins in immunological reactions; and toxins (toxic proteins). A short section is interpolated on the combination of proteins with other substances.

The next section deals with the supply of amino-acids for protein biosynthesis. Here, perhaps, more evidence would have been acceptable that free amino-acids are actual physiological building-stones for proteins. One feels, also, that too much emphasis, for a broadly biological work of this character, has here been placed on animals, to the exclusion of other organisms that are much more adept at synthesizing amino-acids and consequently of greater interest from this point of view.

The final section, on protein synthesis, is, as Prof. Haurowitz says, speculative. He is doubtful whether nucleic acids can have sufficient specificity to be critically determinant in reproduction. Here many will be with him; cytologists have always been uncritical in claiming importance for those substances that are easy to demonstrate. Prof. Haurowitz suggests that nucleic acids act as stretching agents for holding proteins oriented in a two-dimensional arrangement. Identical two-dimensional protein structures are synthesized on such templates, and then undergo three-dimensional folding which is determined by a variety of other cellular constituents. I find it much harder to picture a 'positive' protein template laying down on itself an identical series of amino-acid residues, as Prof. Haurowitz postulates, than to imagine successive positive–negative–positive interaction of a number of complementary structures as in photography and newspaper printing. Here, at least, we have good analogies from the study of immunology, while in analogy to the positive–positive complementarity Prof. Haurowitz quotes only such events as the crystallization of pure amino-acids from solutions of mixed amino-acids, events which are unusual in the experience of many workers. My feeling is that, as usual in biology, much current speculation will turn out to be gross oversimplification. To treat the 'template' idea as axiomatic is to overrun existing knowledge; it is by no means yet proved that amino-acids are built directly into large protein-like molecules without passing through a complicated series of intermediate stages.

Taking it as a whole, students will find this book a stimulating supplement to previous text-books, and research workers in all the fields that are concerned with proteins will find in it new and interesting ideas and references.

R. L. M. Synge

MYXOMATOSIS IN AUSTRALIA

A STEP TOWARDS THE BIOLOGICAL CONTROL OF THE RABBIT

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A REMARKABLY interesting epizootic of the virus disease, myxomatosis, has developed during the past fifteen months in the wild rabbit population of south-eastern Australia[1]. Resulting from the natural spread, on a vast scale, of a deliberately introduced infection, we believe it to be an event without precedent, and the first indication of a pathogen working in the population of a mammal pest in a way that holds promise of achieving a degree of biological control.

After its appearance among laboratory rabbits in South America at the end of last century, and its description by Sanarelli[2], myxomatosis attracted considerable attention from research workers in both the New and the Old World. The mystery of its origin and epidemiology was not cleared up until 1942, however, when Dr. H. B. Aragão[3] showed that the reservoir of the disease was the native Brazilian "rabbit" (a species of *Sylvilagus*), that in this natural host of the virus the infection ran a mild and rather prolonged course, and that it was transmitted in the field by mosquitoes.

It was Dr. Aragão[4] who first suggested that myxomatosis might help to control the rabbit (*Oryctolagus cuniculus*) in Australia. The New South Wales Department of Agriculture obtained virus from him in 1926; and the results of the ensuing laboratory studies were reported by White[5]. The investigations carried out under the ægis of the Council for Scientific and Industrial Research (now the Commonwealth Scientific and Industrial Research Organization) were initiated at Cambridge in 1933 by Sir Charles Martin[6], and continued in Australia by Dr. L. B. Bull and his associates. One of their first concerns was the confirmation of the already fairly clear indication that the virus would be safe to liberate in the field. The virus is, of course, highly pathogenic to both the wild and domesticated forms of the European rabbit, the infection being almost invariably lethal. In contrast, all the common domesticated animals, representatives of the native fauna (mostly marsupials) and the introduced hare (*Lepus europæus*) were found[7] to be refractory.

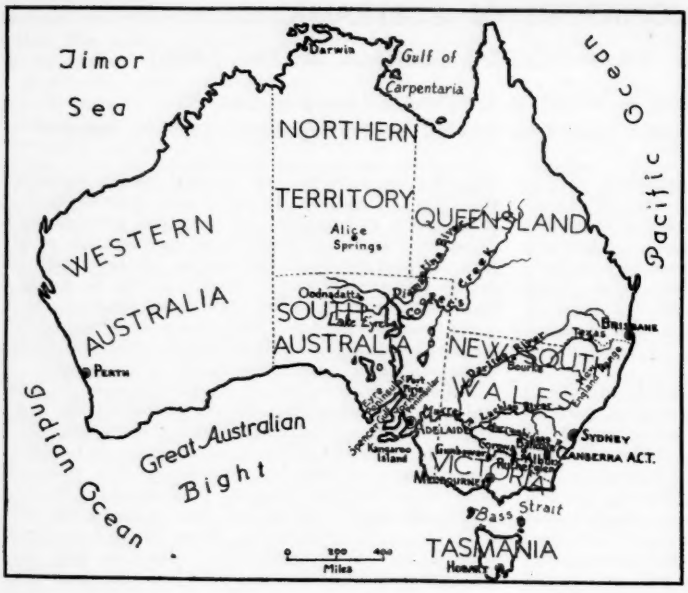
The results of the main Australian investigations have, unfortunately, only been published in summarized form[8]. At the time, it was not known that myxomatosis was essentially an insect-borne disease; but Aragão[9] had discovered that the cat flea (*Ctenocephalides felis*) could transmit the infection, and it was suspected by the Australian workers that insect vectors might assist the spread of myxomatosis in the field. Transmission by the insects considered most likely to be potential vectors in Australia (the stickfast flea, *Echidnophaga myrmecobii*, and mosquitoes) was therefore made the subject of special study in the laboratory. The flea and four species of mosquito were shown to be capable of acting as vectors. The investigations were concluded with a series of field trials, which had to be carried out in isolated localities in the semi-arid pastoral belt—fortunately the favoured habitat of *E. myrmecobii*. The results indicated that the flea transmitted myxomatosis under natural conditions, though its efficiency as a vector was limited by its restricted mobility. They also revealed the interesting fact that foxes, presumably by selective predation on lethargic infected rabbits, could prevent the establishment and spread of the disease. Although spread of the infection from one warren colony to another had occurred in an earlier experiment (carried out in a ninety-acre enclosure), there was no evidence of this taking place in any of the field trials in which the disease was established in unconfined rabbit populations.

A very serious rabbit situation developed in Australia in the years immediately following the War, and the newly established Wildlife Survey Section of the Commonwealth Scientific and Industrial Research Organization decided to re-examine the practical possibilities of myxomatosis. Following the lead of the earlier work, we planned first to carry out field trials in, among other places, areas where mosquitoes were likely to be prevalent. Between May and November 1950 seven liberations of the virus were made on five sites in the Murray Valley, four being in the Albury–Corowa area and one (the site of the earliest liberation) about a hundred miles downstream near the small town of Gunbower, Victoria.

The detail of the history of these trials is not relevant to subsequent events. All were disappointing in that, except in a portion of one of the experimental areas, the disease had no noticeable effect on the rabbit populations. Every site was kept under observation until the infection appeared to have died out, or at any rate had reached so low a level that weeks separated the sighting of sick individuals. By December, observations were concentrated on the two sites where the last (October and November) virus liberations had been made, one in the alpine foothills north-east of Albury, the other near Rutherglen in Victoria.

During the first week in December, myxomatosis flared up on the Balldale test site near Corowa, situated about seven miles north of the river in New South Wales. Almost at once reports began to come in of the appearance of the disease in other places, some on the Murray main stream, some on the northern tributaries. One of the earliest (December) outbreaks, disclosed in later surveys by a colleague, J. Brereton, was on the Darling River nearly four hundred miles from Corowa. There were other almost as surprising, but perhaps less well authenticated, early records.

The widespread dispersal of the virus, which with intensive local spread produced the remarkable epizootic that developed in the next two or three months, cannot be fully and satisfactorily explained, and probably never will be. One thing we believe to be beyond question: the spread of the disease was a reflexion of the movement of infected insects, almost certainly mosquitoes. The relative importance in the general mobility of the vector population of long and short flights, and perhaps the passive carriage on high-level winds, must remain a matter of conjecture. There is presumptive evidence, however, that long flights (or passive transport) were sometimes involved. Nothing else could very well explain the isolated outbreaks that occurred along the southern



margin of the epidemic area, for example, in the dry north-west of Victoria, and, in South Australia, at various points in the Adelaide Hills district, one on Yorke Peninsula, one near Port Pirie at the top of Spencer's Gulf, and one each on the east and west coasts of Eyre's Peninsula. These outbreaks were separated by distances of up to fifty miles. Even more isolated was the one discovered in September 1951 near Alice Springs in Central Australia.

An analysis of the December outbreak records points to the existence of an area, or areas, of disease activity, providing a source of infected insects, prior to the Balldale flare-up. We have failed to obtain direct evidence of such activity; and thus we can only record the possibility that one or more of our earlier and apparently abortive virus liberations may have contributed in some way to what might be termed the embryonic stage of the epizootic.

After the New Year, the epizootic gathered momentum rapidly. By mid-February 1951 myxomatosis had appeared in practically all parts of the huge area that was to be affected before the advent of winter, and the peak of the epizootic had passed in most districts. A feature of this phase that impressed observers was the speed with which the disease swept through local rabbit populations. When high mortalities (of the order of 90 per cent or better) occurred, they were as a rule achieved within 3–4 weeks of the date on which the infection was first noted in the population.

By the end of March a state of general quiescence had been reached; and on the results of our own and colleagues' surveys, and reports received through co-operating State Departments, it was possible to map the epizootic with reasonable accuracy. The most obvious feature of the resulting picture was the close association of the disease with rivers, creeks, irrigation systems and swamps, a clear indication of the paramount importance of water-breeding vectors. (We found that on Beadle's[10] vegetation map of the Western Division of New South Wales, the distribution of flood-zone plant associations delimited with remarkable accuracy the areas in which high rabbit mortalities had been achieved.) Outbreaks of the disease that had occurred in the 'dry' country had as a rule been transient and of low intensity.

The 'myxomatosis map' for the 1950–51 summer is completely dominated by the Murray–Darling system, along most branches of which the disease had spread. The distance, as the crow flies, between the Murray mouth in South Australia and the farthest point on the system reached by the epizootic (the Texas district on the Queensland – New South Wales border) is 860 miles. When one takes into account the coastal areas of New South Wales and Victoria (where State-organized campaigns of virus distribution succeeded in establishing the disease), the outbreaks in south-west Queensland and north-east South Australia extending around Lake Eyre to an area south of Oodnadatta, and the westward spread of the Eyre's Peninsula outbreak already referred to, we find myxomatosis dispersed over an area nearly a thousand miles from south to north, and some 1,100 miles from east to west. The collection of adequate and satisfactory data from so vast a territory presents very obvious difficulties; and the surveys which we, and colleagues in the Organization, have carried out over the greater part of it during the past year have of necessity often been rather superficial.

The marked differences in the performance of myxomatosis in different parts of the Murray–Darling system can be explained by the nature of the season. 1950 was a year of average or sub-average rainfall in Victoria; whereas the north-eastern half of New South Wales and most of Queensland received record-breaking precipitations, resulting in flooding on an almost unprecedented scale in the northern part of the epizootic area. The last flood rains occurred in November 1950; but their effects in the form of abundant surface water lingered for at least a couple of months.

Along the Murray main stream useful 'controlling' kills were confined to a very narrow strip, often only a few hundred yards wide (and usually corresponding closely to the *Eucalyptus camaldulensis* zone), except where irrigation complicated the picture. The same applied in general along the Murrumbidgee. On the Lachlan, farther north, the high-mortality belt was wider, and we found river-fronting grazing properties tens of thousands of acres in area that had been swept virtually from fence to fence by the epizootic. It was, however, in the region lying east and north-east of Bourke on the Darling, with its dendritic development of tributary streams tapping the ranges of New England and south-eastern Queensland, that the most spectacular results were met with. Here the disease became emancipated, as it were, from the waterways as they appear on the map, and the epizootic developed areally. In places it was possible to drive for a day or more through country that had previously been swarming with rabbits and see only isolated survivors.

Two other features of this first phase of the epizootic deserve mention. In general, hills set a limit to the natural eastward spread, the disease rarely penetrating up the rivers beyond the points where they emerged on to the plains. Then there was evidence of the seasonal decrease in vector activity freezing, one might say, the epizootic at a stage when chance effects were still apparent. Areas of eminently favourable country, including substantial stretches of Murray frontage, were by-passed or only feebly invaded by the disease, the active advance of which was rather suddenly curtailed in certain places.

The results of the first, large-scale, impact of the myxoma virus on the wild rabbit population of Australia indicated that the disease would be of material assistance to man in his efforts to deal with the country's most serious animal pest, but also that it might have severe ecological limitations. Epizootics of myxomatosis could only be expected to occur where rabbits co-existed with the right types of insects in adequate abundance; while a usefully high mortality seemed likely to depend on vector densities that would be exceptional in many rabbit-infested areas. It was obvious that no sound assessment of the practical potentialities of myxomatosis could be made, nor could anyone decide how and to what extent the virus could be helped in action, until we knew a great deal more about the insects on which its performance depended.

When we started on our field experiments with myxomatosis, it was known that two species of fleas[8,9] and about half a dozen species of mosquitoes[7,8] could transmit the infection. Shortly after the epizootic got under way a colleague, R. Mykytowycz[11], demonstrated that the common and widely distributed *Culex annulirostris*, and also a species of *Simulium*, played a vector part on the Murray River flats; and later he showed, by laboratory experiments, that the rabbit louse (*Hæmodipsus ventricosus*) and a mite (*Cheletiella parasitivorax*) could act as vectors. The obvious conclusion (which was supported by the results of a laboratory study by Fenner, Day and Woodroofe[12]) was that transmission was mechanical, and that any blood-sucking arthropod that fed on more than one host individual during its lifetime was a potential myxomatosis vector. The relative efficiency of a vector species, and the importance of the role it would take in the epidemiology of the disease, would depend on its ecology and habits, including its mobility, the strength of its preference for the rabbit as a source of a blood meal, and the length of the period of its abundance.

It was clear that the scope of the vector field studies called for was extremely wide. Moreover, the Wildlife Survey Section was handicapped by the fact that practically no relevant information on the potential vector fauna was available—the mosquitoes had been well covered taxonomically, and that was virtually all that one could say.

During the 1950–51 summer it was possible to correlate the performance of myxomatosis in the Murray Valley with the distribution and activity of *Culex annulirostris*; and it seemed safe to conclude that this mosquito, which we found had a strong tendency to remain confined to timber cover close to its breeding-places, had been the principal vector in that area. Heavy rain in mid-February over part of the region produced dense populations of aedine mosquitoes, mainly *Aedes theobaldi* and *A. sagax*. (We planned to pay particular attention to these and other members of the genus that are opportunist exploiters of temporary surface water, and seemed to possess powers of dispersal above the ordinary; for they, among mosquitoes, offered the greatest hope of being able to spread myxomatosis widely and rapidly in country away from rivers and permanent swamps.) Some localized heightening of disease activity, with a spread beyond its earlier confines, pointed to transmission by these species. In view of our later observations, however, and the possibility that some more cryptic species might have been at work, the value of any deduction made at the time as to the vector efficiency of *Aedes theobaldi* and/or *sagax* is questionable.

The second (1951 winter) phase of the epizootic developed almost imperceptibly from the quiescence of autumn. Except in parts of southern Victoria, where a few sharp localized outbreaks occurred that might have been the result of winter mosquito activity (apparently a recognized feature of the coastal belt), this phase was typified by a widespread smouldering of the infection, much of it at such a low level of intensity that it almost escaped notice. In a few places an appreciable mortality was ultimately attained. There were very few winter sightings of sick rabbits in Queensland.

Though the reverse of spectacular, the behaviour of myxomatosis during the winter months was of great interest, and of equally great significance epidemiologically in that it provided a demonstration of the ability of the virus to persist, perhaps indefinitely, in the rabbit population.

Winter activity tended to follow one of two patterns and developed, to our surprise, almost exclusively in areas that had not been reached by the disease during the summer epizootic. (Thus surviving rabbit populations on river frontages, even if substantial, were rarely affected.) Some of the outbreaks were localized around swamps, hillside seepages, etc., suggesting that they had been initiated by wandering mosquitoes 'homing' to water. Others, more diffuse as a rule, showed a marked association with patches of tussock grasses and more particularly saffron thistles (*Carthamus lanatus*).

We were unable to obtain any indication of the identity of the vector or vectors responsible for winter transmission. Except for confirmation of the persistence and activity of mosquitoes (chiefly *Aedes camptorhynchus*) in parts of the Victorian coastal belt, our collections and observations in the outbreak areas were fruitless. We rather suspect that future investigations will reveal that the winter vectors of myxomatosis are ectoparasites.

The third (spring and 1951–52 summer) phase of the epizootic is still in progress at the time of writing. The abnormality of the season has made it, in one respect, disappointing. The lateness and partial failure of the monsoon left a substantial part of the epizootic area in the grip of a severe drought until close on the end of the summer, so we have not been able to obtain the information we had hoped for from Queensland and northern New South Wales.

In the extreme south, along the Victorian coast, the disease appeared on a number of offshore islands early in the spring, and some of the highest mortalities yet recorded were achieved. The species that seems most likely on our present knowledge to have played the main vector part in these outbreaks and in the early activity that developed in parts of coastal South Australia is *Aedes camptorhynchus*, the dominant mosquito of the region and a breeder by choice in brackish swamps.

As our surveys of mosquito breeding grounds had led us to expect, the season opened in the Murray Valley with a widespread emergence of *Aedes sagax* and *theobaldi*. The wave of abundance of these two species was not correlated with any marked general increase in disease activity, such as we were waiting for; and it may be said that a clear indication of the inefficiency of *A. sagax* and *A. theobaldi* as myxomatosis vectors in the field was one of the two most important things to come out of the season's observations—the other being the subsequent demonstration of the vector role of *Anopheles annulipes*.

The surroundings of a lake halfway between the Murray and Murrumbidgee Rivers, selected by one of us (K. M.) as a special study area, provided the stage for a sequence of events that miniatured the large-scale developments which occurred from late November on. The infection was artificially established and maintained in the dense local rabbit population throughout the period of abundance and dominance of Aedines, during which the situation remained static. A dramatic change occurred, however, when *Anopheles annulipes* (accompanied, in lesser numbers, by an unnamed but now well-known species of *Culex*) began to be prevalent; and a very active epizootic was soon under way.

It had been observed that *Aedes sagax* and *theobaldi* attacked stock (especially cattle) in marked preference to rabbits, which might well be the key to their inefficiency as vectors. The fact that *A. annulipes* was feeding on infected rabbits was established by inoculating suspensions of random-caught insects into healthy animals; and some interesting and significant observations were made on its habits. First, it was found to harbour during the daytime in rabbit warrens, as did the *Culex*. (Later, we obtained evidence in another locality that suggested penetration for a considerable distance underground.) Then it was noted that when the rabbits in one section of the area had been virtually exterminated, and the warrens fell into disuse, Anophelines appeared in increasing numbers in the burrows on a well-populated sandhill not far away, where the disease spread quickly. Similar behaviour was observed on other study areas.

The main summer epizootic developed over a vast, roughly crescent-shaped area, extending from the mouth of the Murray in South Australia eastward and then northward, inland of the Great Divide. It covered a substantial part of Victoria (including the south-west coast) and the southern two-thirds of the broad belt of undulating country lying between the mountains and the plains in New South Wales; while there were scattered outbreaks in the highland valleys along its eastern margin. In some regions, notably the Murray Valley, the epizootic built on, and extended, the effects of the previous summer's activity; but for the most part it developed in country that had not been reached by the disease during the first phase of its spread. It is difficult to estimate the relative importance of natural and artificial dissemination of the virus in preparing the way for the second summer epizootic. Winter and spring sightings of sick rabbits had been reported in many, if not most, parts of the affected area; but the State-sponsored inoculation campaigns must have resulted in a more thorough and widespread 'seeding' of the infection than would have been achieved naturally.

We believe that the principal vector in the 1951–52 summer epizootic was *Anopheles annulipes*. Its presence, as revealed by the discovery of adults in the warrens or local breeding, has been the one vector factor common to all those parts of the affected area in which we have been able to make adequate and timely observations. The intensity of disease activity has, in general, been correlated with the distribution of suitable *annulipes* breeding grounds—vegetated swamps, the weedy margins of slow-moving creeks, and waterholes formed by the drying up of hill streams. *A. annulipes* breeds with *Culex annulirostris* in the lagoons of the Murray flats, but it is a much more adaptable and far-ranging species than the latter. *C. annulirostris* probably played a vector part during the summer just passed, in the zone where it occurred; but the indications are that it was forestalled in time and outstripped in range by the Anopheline. Along the Murray, in 1951–52, where conditions made the comparison possible, a useful rabbit kill extended for almost as many miles back from the breeding waters as it did hundreds of yards during the previous summer's epizootic.

During this last phase of myxomatosis activity, high local mortalities were sometimes attained with the rapidity that characterized the 1950–51 summer epizootic; but in several areas the disease worked unobtrusively for two or three months to effect a comparable reduction in the rabbit population density.

In this perforce somewhat oversimplified account of the course of the myxomatosis epizootic from December 1950 to April 1952, it has been impossible to mention many interesting and often puzzling local outbreaks in which vectors other than mosquitoes seem to have been involved. (Discussion of these must await the full report of our field studies.) Our observations have admittedly been deficient in the outlying parts of the epizootic area, and on the eastern seaboard and highlands; and the picture we have presented above reflects this fact. Our main and most intensive investigations have been carried out in northern Victoria and southern New South Wales, where mosquitoes are undoubtedly the most important myxomatosis vectors. In this region our observations now cover the full cycle of the seasons, and the broad pattern of the ecology of the mosquito fauna is now becoming clear, with its succession of species attaining dominance as larval and adult habitats change in nature and extent. The important point is that the course of the epizootic in the Murray Valley can be very satisfactorily explained by the entomological picture that has been disclosed; and we feel that the information gained in this region will be broadly applicable to other areas in which the same species of mosquito occur.

It is clearly necessary to try to answer two questions that are inevitably being asked: What has been the overall effect of the epizootic to date on the rabbit population, and what long-term contribution to a solution of Australia's rabbit problem can we now expect from myxomatosis? Unfortunately, it is not possible to answer either of these questions confidently and satisfactorily.

We have considered most carefully ways and means of giving quantitative expression to our estimate of the efficacy of the epizootic, but have reluctantly abandoned it as impracticable. While we might hazard the guess—which would not be a 'blind' one—that an average overall reduction in the rabbit population of the order of 50 per cent had been achieved in those districts where the disease had been active, such a statement would be of little value

without a quantitative definition and estimate of the areas in question, and this cannot be given. (Appreciation of the vastness of the region involved, and the impossibility of acquiring detailed knowledge of more than an insignificant fraction of it, should make this point self-evident.) A tentative estimate that myxomatosis had been active, that is, had caused an appreciable mortality, in one-fifth of the rabbit-infested country of Victoria, and one-tenth to one-eighth in New South Wales, might be very wide of the mark.

The epizootic, especially during the recent summer, was observed to work more effectively in heavily infested spots, thus "levelling out the peaks" of the variable regional population. One survey, of a sample area of a hundred square miles (64,000 acres) between the Murray and Murrumbidgee Rivers near Albury, revealed that while 20,000 acres were classed as heavily rabbit infested before the epizootic, only 340 acres remained so immediately after it. There are substantial tracts of land in south-eastern South Australia, Victoria, and New South Wales over which rabbit density has been reduced to a very low level, as little as, or even less than, one-tenth of the 1950 figure. Many landholders (perhaps to be numbered in thousands rather than hundreds) have had their personal rabbit problems virtually solved for the time being by myxomatosis; and immediate obvious benefit in the form of increased pasture growth and stock-carrying capacity has been reported from a number of districts.

Our observations indicate that there has been no substantial recovery of the hardest-hit rabbit populations as a result of breeding; but this may be explicable to some extent by the seasonal conditions. In parts of the epizootic area, for example, in Queensland, rabbits reappeared 4–8 weeks after disease activity had ceased, necessitating a reduction in the original, very high, estimate of regional mortality. We can offer no explanation of this temporary disappearance of most of the surviving population.

The epizootic took place at a time when rabbit numbers were generally high; and the area affected included much of Australia's most heavily infested country. With this in mind, and a knowledge of the statistics of the skin and carcase trade, we would say that the rabbits killed by myxomatosis in the period under review could be numbered in tens of millions (rather than in millions—certainly not in hundreds of millions). This estimate is given merely as a matter of general interest. It provides no indication of the 'control value' of the epizootic: no figure for a short-term mortality could do this.

One thing that makes it difficult to assess, on the basis of our analysis of the current epizootic, the importance of the part that myxomatosis will play in the control of the rabbit in Australia is the fact that the 1950–51 and 1951–52 seasons have both been somewhat abnormal. The former provided exceptionally favourable conditions for transmission in northern New South Wales and Queensland; and while the following summer was definitely unfavourable in the north, we are inclined to believe—though this conclusion needs to be checked by future observations—that dry, but not too dry, conditions in the south may have resulted in an unusually widespread prevalence of *Anopheles annulipes*. (For this vector to breed prolifically in the belt of undulating country that benefited most in the 1951–52 epizootic, the spring-fed creeks must be maintained in the right condition for a reasonable period of time, free from flushing on one hand and too great a degree of drying-out on the other.) Another fact that has to be taken into account is that the virus of myxomatosis is still in what might be termed the colonizing stage, and that the future should see it more widely—and at the same time more uniformly—distributed through the rabbit population, and hence better able to take advantage of local conditions favouring rapid transmission.

It is now reasonably certain that myxomatosis will be permanently established as an enzootic infection in the wild rabbit population of Australia. Its long-term overall effects will depend on something more than the summation in space and time of local mortalities. For example, the extent to which rabbits tend to concentrate in, and repopulate by immigration, well-watered country, and the effect of the disease on the development of normal breeding behaviour—two things about which we know next to nothing—may be of critical importance.

Apart from those just given, there is one very cogent reason for hesitating to estimate the future potentialities of myxomatosis. The possible effect of the natural process of mutual adjustment between parasite and host—the myxoma virus and the rabbit—cannot be ignored. The questions involved in this aspect of the myxomatosis problem lie in the specialized fields of the virologist and the geneticist; and they are receiving attention at the present time from Prof. Frank Fenner, of the Australian National University, and others. A close watch is being kept for evidence of changes in the virulence of the virus; and the likelihood of the susceptible rabbit population being replaced, within a period of years rather than decades or centuries, by one possessing a significant degree of resistance to the infection is being examined. Our observations suggest that recoveries in the field have been more frequent than the laboratory indication of virtually 100 per cent lethality would lead one to expect. If recovery is shown to have a genetic basis, the acquisition of some degree of resistance by the Australian wild rabbit population must be regarded as inevitable.

Too many people for individual mention—colleagues in the Organization, officers of State Departments, and landholders in the epizootic area—have helped us in our work. A detailed account of our investigations is being prepared for publication, in due course, as a C.S.I.R.O. Bulletin or in one of the Australian scientific journals. It remains only to record that the enthusiastic and persistent advocacy by a Melbourne specialist in virus diseases, Dame Jean Macnamara, was a material factor in the decision to initiate experiments with myxomatosis in 1933, and to resume field studies in 1950.

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ALCHEMICAL ILLUSTRATIONS*

By Dr. F. SHERWOOD TAYLOR
Director of the Science Museum, London

THE ideas and practice of alchemy are to-day so foreign to the mind of the age that, contrary to our custom, we have felt the need to preface the exhibition of "A Hundred Alchemical Books" by some thoughts about the nature of the art and the character of the illustrations that purport to explain it.

How, then, does alchemy differ from chemistry? On what grounds do we call this book alchemical and that book chemical? As in all distinctions of real things, the line of demarcation is not quite sharp; but the principal difference of alchemy and chemistry is to be found in their purpose. Alchemy was a practical art purporting to make gold from base metals or to perform some other master-work of perfecting some created thing in its own nature: chemistry is a science directed to the investigation of the nature and properties of all kinds of matter. One is a work to be done: the other understanding to be gained.

There are other, though less-essential, differences. Alchemy looked backward. There were great men in the past who had done the work, known the secret and concealed it in their books: the task of the alchemist was to penetrate these cryptic repositories of knowledge, a task of reflexion rather than experiment. Chemistry looks forward, honouring the men of the past, but seeking knowledge never yet in the mind of man, through the process of reasoning and experiment.

Alchemy was a lonely work, to be done and completed by a single worker for his own ends. Were the work once done, the laboratory and its manual tasks would be abandoned and the alchemist would lead a new enlightened life, of which we are told but little.

Chemistry is cumulative, the work of hundreds of thousands, sharing and transmitting the knowledge they gain: it is never-ending, for every research opens the way to more. In all this may be seen the resemblance of alchemy to an art, rather than a science.

Yet alchemy was one of the contributors to chemistry. The very idea of chemistry was unknown until the early sixteenth century. There was a theory of matter, there was alchemy, there was a diversity of practical arts which we should to-day regard as within the field of the chemist, but that all these should be treated as kindred subjects concerned with the transformation of matter was the idea of Paracelsus, who sought to group them together under the name of 'alchemy'. For him alchemy was the way the stomach concocted the food and the doctor prepared the medicine; the smelting of iron was alchemy, as was also what was done by the baker, the cook and even the stoker. In all this we see the ideas of separating the pure from the impure, and the transforming of matter. Nearly a century later Andreas Libavius took the name Alchemia for what we would call the first general text-book of chemistry. Thus in the seventeenth century alchemy had at first the double meaning of the gold-maker's art and the science of chemistry: only gradually was 'Alchemia' reserved to the first and 'Chemia' to the second. Gradually through this century the subjects became separated. Alchemy became ever less chemical and more symbolic, while chemistry relinquished, first its interest, then its belief in the alchemical process.

Alchemy gave more to chemistry than a name. The first chemical laboratory, perhaps the first laboratory, was an alchemical laboratory, and practically all the apparatus used before the period of the study of gases was invented by alchemists, and can be seen illustrated in the books on alchemy.

The ideas of alchemy as expressed in the alchemical works are a tangled web of notions drawn from science, philosophy and religion, but in them it is possible to see a certain broad pattern. That metals were to be transmuted into gold was an idea made acceptable by its promise of release from poverty: that metals could be so transmuted was made credible by the Aristotelian theory of matter, which allowed the possibility of every element being changed to every other. The works of Aristotle also put forward the theory that all metals were compounded in the earth of two exhalations, a moist and a smoky. What Nature could do in the rocks, the alchemist might hope to bring about in his vessels. The idea of these exhalations was akin to that of the all-pervading *pneuma*, spirit or world-soul, which in the Hermetic and Stoic philosophies was at once the material of all things and agent of all changes, operated by the ever-changing influence of the heavenly bodies.

This was the fundamental idea of alchemy: to gather the active spirit (the philosopher's mercury) and make it operate the change of one metal into another. But how to gather it? Somewhere, before about A.D. 100, the process of distillation was invented and provided the means of apparently drawing the volatile active part of bodies—the spirit—out of a great many natural bodies, and in the liquors so obtained were the hopes of the alchemists. From the first century to the eighteenth century they distilled and worked with every volatile body that they knew. Mercury and sulphur were favourites, and known before the accepted date of the beginning of Western alchemy: arsenic trioxide, ammonia, alcohol, the mineral acids were probably alchemical discoveries. Dew was a magical material for them, the direct product of the heavens, and they also distilled every conceivable plant and animal material in search of their 'philosophers' mercury'.

At some time, perhaps during the period of study of alchemy by the Arabs, there arose the idea of a 'medicine' or 'powder', a small dose of which, added to a molten base metal, would transform it into gold. This idea rapidly gained strength in medieval Europe, and a standard process for transmutation was gradually evolved. The philosopher's mercury was to be gathered in some fashion—and this was the secret most sedulously guarded. It was to be set in a sealed vessel with a little gold and silver, often made more mysterious and unattainable by being described as 'our' gold and 'our' silver, and subjected to gentle heat. The gold and silver were depicted as dissolving and 'marrying', forming a double being that died and was corrupted to a black mass, then was revivified, passing through glorious colours to the white stone that transmuted to silver, and by a repetition of the process to the red stone that transmuted to gold, and indeed would perfect every creature in its own kind. It is of little use to try to find a modern chemical equivalent of these supposed changes, for no chemicals

* Substance of an address given at the opening of an Exhibition of Alchemical Books at the Science Museum, London (*Nature*, **169**, 1041, June 21, 1952).

to which the alchemists had access could have produced any of these effects. We may be sure that they did seal up various things and subject them to heat, causing changes which they observed. The more fruitful way of looking at the problem is to ask why they *expected* such changes and why they symbolized them as they did.

What did a chemical change mean to the men of the Middle Ages? It was essentially a generation of a new body and was thought of in terms appropriate to generation. There must be a marriage: gold must generate the seed of gold; so gold, symbolized by the sun, must marry silver, symbolized by the moon. The character of the body produced in any generation was determined by the heavenly influences: the mercury of the philosophers was the physical condensation of those influences. The product was a seed: the seed must die in the ground, as the scripture tells, and from its black and putrefied remains springs the new being, the glorious body of the stone. The myth, if we may so call it, combines the two most potent ideas of man—the idea of marriage and the idea of resurrection and renewal. Is it surprising that the process fired the imagination of the artists?

But why understand a physical process in such terms? Man always desires to understand what he sees or conceives under some visual analogy. We have the atomic theory and conceive our chemical changes as the rebuilding of a structure. With a continuous theory of matter no such picture could be formed, and the human and spiritually oriented philosophers of the Middle Ages saw the chemical change under the analogy of the life of man. Man is generated and born, he dies to sin and is born again, he dies physically and is resurrected; these transformations were what the medieval alchemist expected to see and supposed that he saw in chemical change.

Moreover, by a very characteristic reversal, the alchemists first constructed their view of chemical change on the analogy of man, and in later ages viewed man under the analogy of chemical change. Thus in the later years of alchemy, certain writers, notably Jacob Boehme, symbolized the mystical progress of man by the process of alchemy. The result is a fascinating equilibrium of chemical and mystical ideas, displaying a thousand shifting aspects to be exploited by the writer and his artists. Thus we expect and find in alchemical illustration not only figures of laboratory apparatus, but also every symbol that has a bearing on the ideas of transformation, marriage, generation, death, growth and renewal.

Both representational and symbolic illustrations are found in the alchemical manuscripts written in Greek, the texts in which were mostly written between A.D. 100 and 700. The Arabic manuscripts are, to my somewhat slender knowledge, but scantily illustrated, but certainly contain both elements. The elaborate series of symbolic pictures occurred in medieval manuscripts before they found their way into printed books, and it would seem that the more elaborate did not appear before the fifteenth century.

Printed alchemical books appear from the beginning of the sixteenth century. The first are distillation books, chiefly pharmaceutical, with alchemy taking a minor part. Some of these, such as the magnificent works of Brunschwyg, are illustrated by very fine woodcuts of a representational character. Symbolic alchemical works illustrated by woodcuts appeared at intervals throughout the sixteenth century; but it is in the early seventeenth century that these attain their zenith. About the year 1625 there issued from the presses of De Bry and of Lucas Jennis a stream of finely printed alchemical books, adorned with finely conceived and beautifully executed engravings. As the seventeenth century proceeded, alchemy and chemistry achieved their separation. Chemical works with good plain pictures of apparatus abounded, though these commonly retained some alchemical matter and often a symbolic frontispiece. By the close of the seventeenth century, alchemical illustrations had disappeared from chemical textbooks, while the alchemical works, still produced in great numbers, displayed more of the influence of Rosicrucianism, the Cabala and Free-masonry.

We learn a not insignificant part of the history of chemistry by studying alchemy and its pictures; also our eyes are opened to a view of the world other than the modern scientific—a view which we may regard as a horrifying example of unscientific thinking or as the addition of a poetic and human quality to our outlook on material things. Moreover, we learn something about man, his eternal problems and aspirations, and the manner in which desires and ideology affect his very observations, let alone the interpretation he gives them. We cannot view the scientific way of thinking truly except by a contrast with non-scientific thinking about the same subjects, a contrast for which the Exhibition now at the Science Museum provides material.

OBITUARIES

Sir James Irvine, K.B.E., F.R.S.

With the death, on June 12, of Sir James Irvine, principal and vice-chancellor of the University of St. Andrews, this ancient seat of learning mourns the loss of an illustrious son whose career at St. Andrews extended over a period of fifty-seven years in the successive capacities of student, lecturer, professor and principal. His services to the University, particularly during his tenure of the highest office for more than thirty years, can truthfully be described as inestimable. In that period he changed the face of the University and brought prosperity and high prestige to a time-honoured academic foundation which in his early days was marked by poverty, a paucity of students, and a lack of proper buildings and equipment for the teaching of science.

James Colquhoun Irvine was born at Glasgow on May 9, 1877. After his early education at Allan Glen's School and the Royal Technical College, Glasgow, he entered the University of St. Andrews in 1895 and graduated B.Sc. in 1898. Here he became a brilliant disciple of Thomas Purdie, professor of chemistry, who always remained in his memory. It was during an ensuing period of study under Wislicenus at Leipzig that he conceived the novel idea of applying Purdie's method of methylation to the investigation of the molecular structure of carbohydrates. From this idea sprang the famous carbohydrate research school at St. Andrews, which he developed with so much energy and success during his tenure of the chair of chemistry from Purdie's retirement in 1909 until his own appointment, in 1921, as principal of the University. These pioneer researches led to later work of the first importance in carbohydrate chemistry, much of which was carried out at Birmingham under the direction of Sir Norman

Haworth, who had formerly held an appointment in Irvine's department at St. Andrews.

Irvine's researches were interrupted by the First World War; at the same time, however, the experience of the St. Andrews school was brought into full play in meeting the demands of the British, French and Russians for such indispensable carbohydrates as dulcitol, inulin, fructose, maltose and mannitol. There followed the complete preparation, in quantity, of novocain. These tasks, together with difficult and dangerous work on mustard gas, hindered the expansion of the fundamental researches on carbohydrates. This work was once more getting into stride when Irvine became principal in 1921.

Soon afterwards, the scientific contributions that the new principal had made to the national war effort were recognized by the bestowal upon him of a knighthood; he had been elected a Fellow of the Royal Society in 1918. A portrait of this fourth professor of chemistry in the United College of St. Salvator and St. Leonard, painted some years later (1933) by Oswald Birley, hangs in the Senatus Room of the University of St. Andrews beside that of his teacher, predecessor and friend, Thomas Purdie. A distinguished pupil of Irvine has said that "he was an inspiring teacher, and his lectures were models of clearness. More than that, they inspired in the students a love of chemistry and gave them a desire to take part in the discoveries that Irvine himself was initiating".

Irvine had shown his administrative ability as professor and also as dean of the faculty of science; but few suspected his latent powers until the broad opportunities of the principalship unfolded themselves before him. A profound love for his University and an unfailing faith in its high destiny enabled him to combine the vision of the seer with the drive of the man of action, and to use tradition as the handmaid of progress and development. He cherished the picturesque attributes of his ancient University, and drew into practical service the pageantry and colour of the 'College of the Scarlet Gown'.

During his long term of office, the development of the residential system with its attached Harkness entrance scholarships, together with the institution of regents, played a leading part in widening the field of recruitment of students and in raising their number to an economic level. New chairs were founded judiciously in every faculty of the University. Among many notable advances in the part of the University situated in Dundee were the growth of the schools of medicine and engineering, and the expansion of the chemistry department of University College. These rapid developments, combined with the geographical handicaps imposed upon a University with centres situated upon both sides of the Tay, have inevitably given rise to growing pains. Such difficulties, however great, must be overcome in the interests of the University as a whole. In Irvine's own words (1950): "Let it be an encouragement and an inspiration to each one of us to reflect that, within the history of our own times, obstacles so formidable have been met and surmounted. . . . I have faith, unconquered and unconquerable, in the beloved University of St. Andrews".

Irvine's interests and activities, although concentrated upon the University of St. Andrews, spread outwards in ever-widening circles as the years went by. He took a great and practical interest in preserving the historical character of the city of St. Andrews. In the outside world he rendered invaluable services to the Scottish Universities Entrance Board, the Scottish Education Department, the Forest Products Research Board, the Carnegie Trust, the Pilgrim Trust, the Commonwealth Fund, and many other organizations. He was a member of the Prime Minister's Committee on the Training of Biologists (1931), chairman of the Viceroy's Committee on the Indian Institute of Science (1936), of the Committee on Higher Education in the West Indies (1944), and of the Inter-University Committee on Higher Education in the Colonies (1946–51). He was a prime mover in founding the University College of the West Indies, where the scarlet student-gown of St. Andrews may be seen in a new environment. He was also an ever-welcome visitor to the United States; on various occasions he delivered special lectures and addresses in that country, as at Williamstown (1926), Princeton (1929), and Yale (1931).

He was awarded many honours: in 1948 he became K.B.E.; in chemistry he was Longstaff medallist of the Chemical Society, Davy medallist of the Royal Society, Willard Gibbs medallist of the American Chemical Society, and Elliott Cresson medallist of the Franklin Institute of Pennsylvania. He received numerous honorary degrees from the universities of the homeland, the British Commonwealth and the United States.

He married in 1905 Mabel Violet, younger daughter of Mr. John Williams, of Dunmurry, Co. Antrim. Throughout his subsequent career he owed much to his wife's unfailing devotion and counsel, and to the background of a happy home-life. He had three children, including one son, Nigel, who died on active service during the Second World War.

It is difficult to do justice in words to Irvine's many-sided character and personality. A richly stored mind found expression in speech that could attain a rare eloquence and charm, whether at great moments or upon more intimate occasions. He was an admirable chairman, ever ready to lighten the routine of business with an apt anecdote or reminiscence. He had a remarkable power of reducing a complicated problem to its essentials; at the same time, he had an equally remarkable memory for detail of all kinds. Persuasive in argument, tenacious of opinions carefully formed, he showed the greatest determination and forcefulness in carrying through a cherished project passionately held. He was a stern disciplinarian when occasion demanded; yet his students knew instinctively that in him they had a firm friend. He had, indeed, a discerning sympathy with youth; he would sometimes pause at his desk in the midst of the weightiest matters in order to write a charming letter of encouragement or of congratulation to a youthful acquaintance: from him came many kindnesses of which the world knew nothing. In himself he preserved throughout his life a certain element of spiritual boyishness, allied closely with his eager zest for new knowledge and fresh experiences.

Two years ago Irvine wrote: "I find myself—a twentieth-century scientist—gazing across the chasm of five hundred years to a strange remote world and am conscious afresh of a feeling which never entirely escapes me that, as the thirty-fourth Principal of St. Salvator's College, I am privileged to share in the inheritance of a solemn trust; at once I am brought face to face with the question if the duty committed to that long succession of Masters has been faithfully discharged". The answer is clear to us and will be even clearer to posterity.

John Read

Dr. F. W. Carter, F.R.S.

FREDERICK WILLIAM CARTER, who was until his retirement in 1946 consulting engineer with the British Thomson-Houston Co., died on May 29 at the age of eighty-one.

A man of impressive appearance and of great mathematical ability, he was nevertheless very modest, gentle and reserved. He was almost the first mathematician of high order to apply his abilities exclusively to the practical problems arising during the development of a great engineering industry, and in so doing he built up a world-wide reputation. Behind the mathematics which he used so successfully, he had a clear physical conception of the problems with which he dealt, and in many cases saw the form of the answer before the problem had been worked out in detail. So his analyses included those factors which would give a satisfactory engineering answer, and ignored factors not significant. All his writings are models of lucidity and of the economical use of words, and are a pleasure to read in spite of the difficulty of the subject-matter.

Dr. Carter's choice of subjects was very wide; the first paper published in 1898 dealt with "The Smashing Point of a Glow Lamp"; the last, published in 1944, with "Anti-aircraft Gunnery". Between these two extremes he ranged over many problems both electrical and mechanical. His papers were published in the *Proceedings* of the Royal Society, of the Cambridge Philosophical Society, of the Institution of Civil Engineers, of the Institution of Electrical Engineers, and in many of the important technical journals.

By electrical engineers Dr. Carter will always be remembered for his investigations on magnetic fields in electrical machines. In this work he used the Schwarz–Christoffel transformation, described by J. J. Thomson in "Recent Researches in Electricity and Magnetism". He was the first to apply it to a practical engineering problem, and after a lapse of time, while engineers acquired an understanding of this weapon of attack, others followed his lead. Three papers on this subject were published: one in 1900, another in 1901, and the third, where he collected the results of his researches, in 1926. 'Carter's coefficients', quoted in text-books on electrical design, and used by electrical machine designers, were derived from this work and perpetuate his name.

In mechanical engineering Dr. Carter completed one investigation of outstanding originality. It relates to the running characteristics of locomotives with special reference to their stability of operation. He began, in a paper on "The Electric Locomotive" in 1916, by propounding a theory to explain unstable running of locomotives, introduced and defined a new quantity which he called 'creepage', and made a qualitative analysis for conditions of stability. The subject was developed in two further papers in 1926 and 1928, based on Love's work on elasticity and Routh's work on criteria of stability. A final paper, in 1930, applied these earlier results to analyse the characteristics of certain locomotives involved in derailment accidents. Using models, he gave a practical demonstration of the correctness of his theory at a conversazione of the Institution of Civil Engineers in 1929.

One further sample of his work is worthy of special mention. In 1922 he published a book on "Railway Electric Traction". Thirty years later it is still accepted as the standard book dealing with the fundamentals of the subject.

In addition to his published works, comprising thirty-four papers and one book, he carried out many investigations for the British Thomson-Houston Co., which he served during almost the whole of his professional career. One of these, in 1939, was the determination of stresses in a large forging during heating and cooling and in the transition from the plastic to the elastic state.

He entered St. John's College, Cambridge, in 1892, taking his degree in 1895, when he was placed eighth wrangler. In 1926 he was awarded the Sc.D. degree at Cambridge, the first in the Faculty of Engineering for more than fifteen years, so far as can be traced in the records. He was elected a Fellow of the Royal Society in 1932. He became a full member of the Institution of Civil Engineers in 1919, and was awarded the George Stephenson Medal and the Telford Premium by the Institution. He became a full member of the Institution of Electrical Engineers in 1912, and was awarded a premium for his work on magnetic fields.

He married in 1908 Edith, youngest daughter of James Cramp, of Coventry, and sister of Prof. William Cramp. He is survived by his widow and three sons, the eldest of whom is Prof. G. W. Carter, professor of electrical engineering in the University of Leeds.

K. R. HOPKIRK

NEWS and VIEWS

Meteorology in the University of London: Sir David Brunt, F.R.S.

SIR DAVID BRUNT is retiring in September from the chair of meteorology in the University of London and the post of head of the Department of Meteorology in the Imperial College of Science and Technology, London, to which he was appointed in 1934. The Department, the only one devoted to the subject in a British university, has greatly flourished under Sir David's direction and has attracted students from all parts of the world. The research work carried out there has much increased, and the teaching staff, apart from Sir David, has grown to five and includes two University readers. After a brilliant career in mathematics at the Universities of Wales and Cambridge, Sir David became a meteorologist in 1916 as an officer of the Meteorological Section, Royal Engineers. On demobilization in 1919 he was appointed Superintendent of Army Services in the Meteorological Office. This post involved control of meteorological work in chemical warfare and ballistics; thus the study of turbulence and diffusion in the lowest layers of the atmosphere, to which he has since contributed so much, became a major official responsibility. During his service in the Meteorological Office he also made important contributions to the study of periodicity in European weather, to radiation, and to the dynamics of depressions and anticyclones. Shortly after his appointment in 1934

to the Imperial College, he produced his monumental book "Physical and Dynamical Meteorology", in which was given the first full, connected and critical account of those aspects of meteorology. Since then, while not neglecting radiation and turbulence, Sir David has worked mainly on cloud formation by eddy motion, on the effect of atmospheric conditions on human comfort and capacity for work, on the meteorology of soaring flight, and on the application of meteorology to agriculture and industry.

Sir David was elected to the Royal Society in 1939, received a Royal Medal in 1944 for his contributions to meteorology, and became a secretary in 1948 and a vice-president in 1949. He was knighted in 1949. He has also been president of the Royal Meteorological Society, from which he received the Buchan Prize in 1933 and Symons Medal in 1947, and of the Physical Society. He has been a member of the Meteorological Research Committee of the Air Ministry from its formation in 1942. Sir David's work has covered a very wide range and has been characterized by strict adherence to physical reality leading to results of immediate practical value. He has had great influence in stimulating among meteorologists the application of exact physical reasoning to meteorological problems, and among Service officers and engineers in revealing to them the help which meteorology can give in the solution of their problems.

Mr. P. A. Sheppard

Mr. P. A. Sheppard, University reader in meteorology in the Imperial College, is to succeed Sir David Brunt. He was born in 1907, graduated in 1927 at the University of Bristol with first-class honours in physics and joined the staff of the Meteorological Office in 1929 as resident observer at Kew Observatory. His early work lay largely in the field of atmospheric electricity, and he took part in the British Polar Year expedition of 1932–33 to Fort Rae in Arctic Canada as the specialist in that subject. Shortly after returning from Canada he joined the Meteorological Section of the Chemical Defence Establishment, Porton, and there investigated problems of wind structure in the layers of atmosphere just above the ground. To aid in this work he designed a sensitive cup anemometer of very low inertia and with a linear calibration curve which would record in a wind as light as 40 ft./min. His paper on the aerodynamic drag of the earth's surface published in the *Proceedings of the Royal Society* in 1947 describes a study of the wind drag on a torsionally mounted plate, and establishes the validity of von Kármán's constant in the terrestrial boundary layer. Mr. Sheppard left the Meteorological Office in 1939 to go to the Imperial College; but the outbreak of war brought him back to the Office in the autumn of the same year. His major work during the War was the technical direction of the work of the British *radiosonde* observing stations and of the meteorological reconnaissance aircraft. He also collaborated with Dr. Sverre Petterssen and others at the Central Forecast Office in devising techniques for the use of upper air information in forecasting and in work on the determination of the large-scale vertical currents from the structure of horizontal wind flow. He returned to the Imperial College in 1945 and since then has been actively interested in atmospheric turbulence and cloud structure. He has served the Royal Meteorological Society as a secretary and as editor of its *Quarterly Journal*. Another valuable service to his fellow meteorologists has been the writing of the surveys of progress in meteorology published in *Science Progress*. He is a member of the Air Ministry Meteorological Research Committee, chairman of its Instruments Sub-Committee, and an original member of the Civil Aviation Research Committee.

Zoology at Reading: Prof. C. H. O'Donoghue

Prof. Charles H. O'Donoghue will retire from the chair of zoology in the University of Reading in September. Prof. O'Donoghue graduated with first-class honours in zoology and physiology in the University of London (King's College) in 1908, and was appointed assistant to the professor of zoology at University College, London. In 1912 he was awarded the degree of D.Sc. and a Beit Memorial Fellowship for Medical Research. He spent six months in Freiburg in 1913 under Prof. Doflein, the protozoologist, and in the following year was elected a Fellow of University College, London. In 1918 he went to Canada as professor of zoology in the University of Manitoba, and was elected a Fellow of the Royal Society of Canada in 1922. He was a member of the Biological Board of Canada. He spent five summers at the Pacific Coast Biological Station at Nanaimo, Vancouver Island, and acted as director during 1923. In 1926 he was visiting professor for two terms at Stanford University, California. He also took part in two biological expeditions to Jasper Park in the Rocky Mountains.

Returning to Great Britain in 1927, Dr. O'Donoghue served under the late Prof. J. H. Ashworth as senior lecturer, later reader, in zoology, in the University of Edinburgh. He was elected a Fellow of the Royal Society of Edinburgh and served on the Council of the Royal Physical Society, becoming its president in 1933. In 1932 he was awarded the Neill Prize and Gold Medal of the Royal Society of Edinburgh for his published researches in the *Transactions* of that Society, and in 1937 was made biological secretary. He became professor of zoology in the University of Reading in September 1939, on the retirement of Prof. F. J. Cole. A new department was being built, and though the outbreak of war caused a cessation of work, building was later resumed and the Department was opened in December 1942. Prof. O'Donoghue was dean of the Faculty of Science during 1944–48, and deputy vice-chancellor of the University during 1950–52. His researches have covered a wide field in zoology. Under Prof. J. P. Hill at University College, he worked on the mammary gland and corpus luteum of marsupials. He has published numerous papers on the vascular system of fishes, amphibians and reptiles; his study of the blood-vascular system of the tuatara, *Sphenodon punctatus*, has become a classic. His later work is taxonomic, and he is an authority on the Nudibranchiate Mollusca and the Bryozoa, having described collections from many parts of the world. Prof. O'Donoghue is a member of the Council of the Zoological Society of London.

Prof. A. Graham

Prof. Alastair Graham has been elected to succeed Prof. O'Donoghue. He graduated with first-class honours in zoology in the University of Edinburgh in 1929, and then took up an appointment as lecturer in zoology in the University of Sheffield, leaving in 1933 to become reader in zoology at Birkbeck College, University of London, under the

late Prof. H. G. Jackson. In 1943 he was made head of the Department and professor of zoology in 1947. Prof. Graham is a governor of Birkbeck College. As chairman of the Board of Studies in Zoology, and of the Board of Examiners in Zoology, he has given valuable services to the University of London. Prof. Graham can look back with pride on his achievement in keeping the Department at Birkbeck College going during the War. In 1940 the Zoology Department was destroyed by bombing, though most of the teaching specimens were salvaged. The Department was set up in the condemned building of Graystoke, and when further bombing restricted its activities, classes were carried on in a cellar, and on several occasions in the open air. He preserved the continuity of the Department through every calamity and raised it to its present high status—a department consisting almost exclusively of part-time students, of whom one-fifth are engaged in research for higher degrees. Prof. Graham's research work has been on the functional anatomy of molluscs, with special reference to feeding habits, and the structure and function of the alimentary canal. He has recently been awarded the Keith Prize of the Royal Society of Edinburgh for the period 1949–51.

Sir George Thomson, F.R.S.

A FAREWELL dinner was held on June 24 at the Imperial College in honour of Sir George Thomson, who after twenty-two years as head of the physics department is leaving on August 1 to become Master of Corpus Christi College, Cambridge. The Rector of the Imperial College, Sir Roderic Hill, presided at the dinner, and the Governing Body was represented by its chairman, Viscount Falmouth. Nearly one hundred people attended, representative of present and past members of the staff and the research students; and on their behalf a presentation was made to Sir George of a watchmaker's lathe, this being suitable for the miniature model-making which is Prof. Thomson's favourite hobby. Prof. W. D. Wright, speaking on behalf of the departmental staff, recalled that it was twenty-five years ago, almost to the day, that a letter had appeared in *Nature* entitled "Diffraction of Cathode Rays by a Thin Film"; that letter marked the beginning of Sir George's well-known researches in electron diffraction. Since 1930, at Imperial College, Sir George had directed notable researches in electron diffraction, nuclear physics and cosmic rays, and he had also given valuable service to the Government as a scientific adviser, both during and after the War. Many personal tributes were paid to Sir George by subsequent speakers, who included the Rector, Viscount Falmouth, Prof. H. Dingle and Prof. H. Levy. They emphasized in particular Sir George's penetrating scientific insight, and the deep respect which he had won from all associated with him. Just as his distinguished father, Sir Joseph Thomson, had been affectionately known in his laboratory as "J.J.", so Sir George was always referred to as "G.P.". He takes with him to Cambridge the good wishes of all at the Imperial College of Science and Technology.

Peter Artedi: A Contemporary of Linnæus

THE yearbook for 1950–51 of the Swedish Linné-Sällskapets (Årg. 33–34, 1950–51; pp. iii+188; Uppsala: Almquist and Wiksell, 1951) includes two contributions by Dr. O. Walde and Prof. H. Engel dealing with the biography of Peter Artedi, the friend and fellow student of Linnæus. Artedi was accidentally drowned in 1735 before completing his important work on ichthyology on which his reputation rests. His manuscripts were saved by Linnæus, who edited and published the "Ichthyologia" in 1738, adding a brief biography of the author. Very little is known of Artedi personally, and only one of his letters has survived. Dr. Walde has discovered, in the Royal Library at Stockholm, a small volume dealing with alchemy, botany and agriculture, which was recognized as the work of Artedi. Prof. Engel relates that Artedi lived a lonely life, going to the tavern from 3 to 9 p.m., working from 9 p.m. to 3 a.m., and sleeping from 3 a.m. to noon. This article comments on some of the legal documents connected with Artedi's death and on the personal effects left by him.

A New Anti-malarial Drug: 'Daraprim'

'DARAPRIM', a new anti-malarial drug, has recently been put on the market by Messrs. Burroughs Wellcome and Co. It is 2 : 4-diamino-5-*p*-chlorophenyl-6-ethylpyrimidine, and is the most active of a large series of substituted 2 : 4-diamino-pyrimidines which have been synthesized and tested against laboratory infections of *Plasmodium gallinaceum* in chicks and *P. berghei* in mice (Falco *et al.*, *Brit. J. Pharmacol.*, 6, 185; 1951). Trials in quiescent cases of human malaria have been reported by Archibald (*Brit. Med. J.*, ii, 821; 1951), and in overt infections of *P. falciparum* and *P. malariæ* in man by McGregor and Smith (*Brit. Med. J.*, i, 730; 1952). They concluded that it has a powerful action on schizonts and a lesser and inconstant action on trophozoites. It acted as swiftly in non-immunes as in others possessing partial immunity; it is tasteless and no toxic reactions of any kind were observed. The drug is an effective suppressant of *P. falciparum* infections, even in doses as small as 5 mgm. daily. Goodwin (*Brit. Med. J.*, i, 732; 1952) took this amount daily for one year. During this time he deliberately exposed himself to the bites of four mosquitoes later shown to be infected with *P. falciparum*. He also slept without a mosquito net for six months while in West Africa. Throughout this period there were no toxic manifestations, and no abnormalities were produced in the blood, bone marrow, or urine. To each of a group of volunteers in England, 50 mgm. of the drug was given twice weekly for three months. Again there were no demonstrable effects on the urine, blood, or erythrocyte sedimentation-rate. Although it is too early to assess the value of this drug, and there are as yet no reports on its action in *P. vivax* infections, its schizonticidal efficiency in *P. falciparum* and *P. malariæ* infections appears to lie between that of paludrine and chloroquine, and it may prove to be a highly efficient malarial suppressant.

Geophysical Research Aboard the R.R.S. *Discovery II*

THE R.R.S. *Discovery II* has recently set sail on the second of its current series of research cruises (see *Nature*, May 24, p. 866), and is expected to be at sea for five to six weeks, going about six hundred miles seaward. The main purpose of the cruise is to elucidate the structure of the sea-bed by taking samples of the top strata and by seismic refraction 'shooting' at short and long ranges. The geological sampling will be carried out both in shallow and deep water by means of specially designed coring-tubes,

capable of taking cores of the bottom sediment up to 30 ft. in depth. The seismic work will consist of refraction 'shooting' at short range (that is, up to a distance of twenty miles) in shallow water, and at long range (up to a hundred miles) on the edge of the continental slope, on the slope itself, and in oceanic depths; for the short-range work only one ship, equipped with sono-radio buoys, is required, but two ships are necessary for the long-range observations, and H.M.S. *Scott* will assist in this. Other work to be attempted during the cruise will include heat-flow measurements through the bed of the ocean, at a depth of about 2,000 fathoms (12,000 ft.), these observations being made with a specially devised probe which is driven 10 ft. into the bottom sediment and allowed to remain there for a specified time. The purpose of these measurements is to determine whether the heat-flow through a continent originates from radioactivity of the continental-type rocks which are, to a large extent, absent under the oceans. Wave recordings, with the special ship-borne wave recorder fitted for the previous cruise, will be continued as a normal routine, and special attention will be given to echo-sounding, more particularly on the continental slope and in deep water. The ship is operated by the National Institute of Oceanography; during this voyage it will work in co-operation with the Department of Geodesy and Geophysics, University of Cambridge, and the following men of science, among others, will be on board during parts of the cruise: Dr. E. C. Bullard, director of the National Physical Laboratory, Teddington; Prof. W. B. R. King, Department of Geology, and Dr. M. N. Hill and Mr. B. C. Browne, of the Department of Geodesy and Geophysics, Cambridge; and Dr. H. F. P. Herdman, of the National Institute of Oceanography.

Indian Jute Mills Association Research Institute

The formal opening by the Prime Minister of India, Mr. Nehru, on January 2, of the new buildings of the Indian Jute Mills Association Research Institute in Calcutta completes the second part of the Association's post-war scheme of co-operative development, which had already been partly realized by the inauguration of a training college for apprentices (*Nature*, 167, 1058; 1951). The Research Institute, founded in 1936 to provide the type of service usually given by research associations in Britain, was originally housed in central Calcutta, under conditions which left a good deal to be desired by the scientific workers on the staff, and in 1945 it was decided to provide more adequate accommodation in the suburbs. The new premises provide modern amenities for a staff of 85, including 45 qualified scientific men or technologists. Laboratories for physics (4), chemistry (4), biological sciences (3), X-ray crystallography, optics, testing, dyeing, finishing, and chemical technology; administrative offices, a lecture room, library, canteen, stores and workshop occupy most of the 50,000 sq. ft. of floor space in the two-storied air-conditioned building. Among the laboratory services are included laid-on compressed air and vacuum. In order to prepare the staff for making the best use of the new laboratories, senior members of the various sections (physics, chemistry, testing, etc.) have been sent to Great Britain during the past five or six years for training in research; the majority of these went to the University of Leeds and qualified for higher degrees in textile science or technology. The director of research of the Institute is Dr. W. G. Macmillan.

Safety of Domestic Electrical Installations

A paper entitled "Domestic Electrical Installations—Some Safety Aspects" was presented on January 24 to the Utilization Section of the Institution of Electrical Engineers by Mr. H. W. Swann, who is senior electrical inspector of the Factory Department of the Ministry of Labour and National Service. The paper gives a comprehensive review of the hazards commonly arising from electrical faults in domestic consumers' installations, and of the methods of protection employed and their limitations. Statistics relating to fires attributed to electrical causes are quoted for the period 1946–50, and attention is directed to the question of the effect of the age of electrical installations on fire risk. Detailed consideration is given to the effect of leakage current on fire and shock risks. It is emphasized that with the increased load now taken by many domestic consumers, normal fuse-settings are often sufficiently high to prevent operation with the maximum fault current that can flow in the 'earth loop', and in this connexion the advantages and limitations of earth-leakage protection devices are discussed. It is suggested that changes in method may become necessary and that the inspection and test of protective devices may prove to be more practicable than large-scale inspection and test of installations and appliances already in use. The paper constitutes a much-needed reminder that means of protection of consumers' installations which were satisfactory at an earlier stage, when electrical energy was utilized on a much smaller scale than to-day, are being rendered ineffective by the sheer growth of the consumption of electricity.

Training of Designers for the Printing Industry

A report on the training of designers for the printing industry prepared by a subcommittee of the London and Home Counties Regional Advisory Council, Higher Technological Education (Report No. 11; obtainable from the Council, Tavistock House South, London, W.C.1; pp. 20; 1952; 1*s*.), recommends that training courses for this purpose should be held in, or in association with, colleges containing reasonably comprehensive departments of printing. In allocating practical accommodation to classes in colleges, it is recommended that priority should be given to classes for apprentices under the indenture approved by the Joint Industrial Council. Local education authorities are recommended to ensure that their scholarship arrangements permit financial assistance for specially selected apprentices attending part-time classes to transfer to full-time attendance for a course in design, and trade associations should consider offering a limited number of scholarships to enable gifted apprentices to take full-time courses in design. Practical instruction in trade processes—to the limited extent recommended—should, for students in a four-year full-time design course, be confined to the last two years. The report is manifestly concerned solely with technical education—the basic principles by which the training of designers for the printing industry should be guided in the future. Nowhere in the report is there any concern with higher technological education, and on the evidence of this report the title itself of this Regional Advisory Council is one more illustration of the sad confusion between technical and higher technological education which appears to be impeding the formulation of an adequate and effective policy for either.

Society of Cosmetic Chemists of Great Britain: Officers for 1952–53

THE fourth annual general meeting of the Society of Cosmetic Chemists of Great Britain, which is an associate of the Society of Cosmetic Chemists (U.S.A.), was held at the St. Bride Foundation Institute, London, on June 13. Mr. W. A. Poucher was elected as the Society's first honorary member. The following officers and members of council were elected for the year 1952–53: *Chairman*, Dr. R. H. Marriott; *Vice-Chairman*, F. V. Wells; *Honorary Secretary*, F. Hulley (24 Bride Lane, Fleet Street, London, E.C.4); *Honorary Treasurer*, E. Polan; *Members of Council*, A. B. Bell, Dr. H. W. Hibbott, H. Holmes, Dr. A. W. Middleton and J. Pickthall.

University of Glasgow: Appointments

THE following appointments have been made in the University of Glasgow: G. Hoyle (zoology) and R. B. Morrison (bacteriology) to lectureships; F. C. Flack (physics) and M. F. Grundon and H. J. E. Lowenthal (organic chemistry) to Imperial Chemical Industries, Ltd., research fellowships. P. A. Sweet, lecturer in astronomy, has resigned from the University on his appointment as assistant director of the London University Observatory and lecturer in astronomy at University College, London. The following promotions have been made in the University: Dr. G. Pontecorvo (genetics) and Dr. H. S. D. Garven (histology) to readerships; J. R. Atkinson (natural philosophy), J. A. Downes and Dr. J. D. Robertson (zoology), and Dr. J. D. Loudon and Dr. J. C. Speakman (chemistry) to senior lectureships; B. W. Ribbons (botany) and I. C. Smith (zoology) to lectureships.

National Research Council of Canada Scholarships for 1952–53

THE National Research Council of Canada has recently announced the award of its scholarships for the academic year 1952–53. The details are as follows, with the corresponding figures for last year in brackets. Altogether 241 (215) awards have been made, totalling 227,900 (192,100) dollars in value, of which 65 (72) are bursaries, worth 600 dollars each, 114 (92) are studentships worth 900 dollars, and 39 (30) are fellowships at 1,200 dollars each. Eighteen special scholarships at 1,500 dollars have been awarded for study in universities or institutions abroad, to be held as follows: four at Cambridge, three at Oxford, two each at Cornell, London and North Carolina, and one each at Chicago, California, Edinburgh, Illinois and at the John Innes Horticultural Institution, Hertford. Five overseas post-doctorate fellowships at 2,500 dollars have been granted for work at universities, two being at Oxford, and one each at Cambridge, Dublin and London.

Institution of Electrical Engineers: Premium Awards

THE Institution of Electrical Engineers has made the following award of premiums for papers read or accepted for publication during the session 1951–52. *Institution Premium:* D. P. Sayers, Dr. J. S. Forrest and F. J. Lane. *Kelvin Premium:* Dr. A. L. Cullen. *John Hopkinson Premium:* T. H. Flowers. *Non-Section Premiums:* Dr. H. L. Haslegrave (Llewellyn B. Atkinson Premium); J. E. Flood and Dr. J. R. Tillman; and P. R. Howard. *Measurements Section Premiums:* Prof. F. C. Williams, Dr. T. Kilburn, G. E. Thomas and Dr. A. A. Robinson (Silvanus Thompson Premium); D. F. Lawden (Mather Premium); and J. V. L. Parry. *Radio Section Premiums:* Dr. R. N. Bracewell, Dr. K. G. Budden, J. A. Ratcliffe, Dr. T. W. Straker and Dr. K. Weekes (Duddell Premium); T. Kilvington, F. J. M. Laver and H. Stanesby (Ambrose Fleming Premium); Dr. A. T. Starr, T. H. Walker, H. Grayson, T. S. McLeod, R. A. G. Dunkley, G. Dawson, G. King, L. Lewin, J. Lipinski and J. B. Setchfield; D. J. Harris and R. J. Ryan; J. T. Machowicz; N. G. Meadows; P. N. Prior and A. J. Walsh.

Announcements

THE Albert Medal of the Royal Society of Arts has been awarded to Sir Frank Whittle for the development of the continuous-combustion gas turbine and jet propulsion.

SIR ALAN DRURY is to retire on September 30 from the post of director of the Lister Institute of Preventive Medicine. He will be succeeded by Dr. A. A. Miles, deputy director of the National Institute for Medical Research and director of its Department of Biological Standards.

THE following announcements have been made by the University of London: Mr. J. R. Napier, lecturer in anatomy at St. Thomas's Hospital Medical School, has been appointed to the University readership in anatomy tenable at the Royal Free Hospital School of Medicine from October 1. E. C. Cherry, an appointed teacher at the Imperial College of Science and Technology, has been awarded the degree of D.Sc.(Eng.).

THE title and status of reader in zoology in the University of Leeds has been conferred upon Dr. T. Kerr, senior lecturer in the Department of Zoology. Dr. R. Brown, reader in plant physiology in the Department of Botany, has been granted leave of absence by the University for the period October 1, 1952–September 30, 1953, to enable him to accept an invitation to an appointment as visiting professor at Cornell University.

AN 'open-day' will take place at the National Fruit and Cider Institute, Research Station, Long Ashton, Bristol, on July 15, when the annual meeting of members will be held and the laboratories, cider house, etc., inspected.

A SYMPOSIUM on New Research Techniques in Physics will be held at Rio de Janeiro, São José dos Campos and São Paulo, Brazil, during July 15–29, under the joint sponsorship of the Brazilian Academy of Sciences, the National Research Council of Brazil and the Centre of Scientific Cooperation for Latin America (Unesco). Further information can be obtained from Prof. J. Leite Lopes, Centro Brasileiro de Pesquisas Fisicas, Avenida Pasteur 250, Rio de Janeiro.

PROF. J. Z. YOUNG asks that attention be directed to a mistake in the description of the support provided for research on the flying spot microscope described in *Nature* of June 7, p. 963. This work has been made possible by grants from the Nuffield Foundation and from the Research and Development Division of the British Steel Founders' Association which, in connexion with its industrial health research, is particularly concerned with the high-speed counting of dust particles.

IDENTIFICATION OF ORGANIC COMPOUNDS FROM INFRA-RED SPECTRA

By Dr. A. E. MARTIN
Sir Howard Grubb, Parsons and Co., Newcastle upon Tyne

MOST organic chemists are well aware of the assistance to be gained from a study of the infra-red spectra of their compounds; but probably many do not realize just how valuable infra-red data could be if a complete catalogue of spectra were available. At the present time several organizations, mainly in the United States, are collecting spectra from many laboratories; but the total number has scarcely reached 3,000 and is only increasing at the rate of about 1,000 per annum, so that clearly progress will have to be greatly accelerated if anything like a complete catalogue is to become available in an acceptable period of time.

It is the purpose of this article to point out that with a little concerted effort fairly complete data of the spectra of organic compounds could be recorded in a reasonable period, notwithstanding that a recent estimate[1] puts the total number at about 500,000, of which some 70,000 can be regarded as the more common; this is approximately the number listed in the "Dictionary of Organic Compounds" by Heilbron and Bunbury. A simple method of recording and filing spectral data is also described.

Experimental Procedure

A modern double-beam spectrometer with rock-salt prism is capable of recording a spectrum from 2 μ to 15 μ with sufficient resolution for our needs in twenty minutes or less, so that allowing for repeat runs and the fact that for the present purpose it is only proposed to use the spectral region 7–15 μ, it should be possible to record the spectrum of a given substance in one hour, say eight compounds per day, 40 per week and 2,000 per annum. With ten instruments fully occupied in this way, 20,000 spectra could be recorded in a year, 100,000 in five years and 500,000 in twenty-five years.

It is desirable that the work should be carried out with a comparatively small number of instruments, since then greater control could be exercised over the accuracy and uniformity of the results. It would be a simple matter to arrange for each instrument to record the spectrum of a given test substance once a week, so that a high standard of accuracy could be maintained.

The question of how a spectrum shall be obtained from a given substance is one of considerable difficulty, and careful consideration is desirable before deciding on a rigid procedure. Comparatively few compounds exist as liquids or solids of low melting point; these can be examined in the liquid state. Many substances can be examined in solution at low concentration (about 1 per cent) in carbon disulphide or carbon tetrachloride, while intractable materials of high melting point and low solubility can be examined as a suspension in 'Nujol' (medicinal paraffin). The 'Nujol' technique is extremely useful, as practically any organic substance, liquid or solid, can be examined in this way. Inevitably a fair proportion of the incident radiation is scattered and lost, but in general this need not exceed 30 per cent. 'Nujol' has strong absorption at 1,450 and 1,375 cm.$^{-1}$, but this latter band causes little interference below 1,350 cm.$^{-1}$ and no other important absorption is encountered in the region used. In the case of rare substances or very small samples, an adequate spectrum can be obtained with as little as 30 μgm. by using a simple reflecting microscope in conjunction with the spectrometer.

The supply of pure substances from laboratories all over the world would be necessary for the successful operation of the scheme; but this should present no great difficulty since the quantity required is very small.

For the purpose of recording the salient features of a spectrum, the positions of the six most intense bands will in general be sufficient. The concentration of the substance under investigation and the length of cell would be chosen so that the strongest band reaches about 80 per cent absorption. Bands will then be quite sharp and the relative intensity of the stronger ones readily determined. If the weaker of the six bands correspond to less than about 20 per cent absorption, it will be desirable to record further spectra at a higher concentration or with a longer length of cell.

The region of the spectrum to be utilized is limited to 650 to 1,350 cm.$^{-1}$ (the so-called fingerprint region), since the frequency-range 1,350–5,000 cm.$^{-1}$ is unsuitable for our present purpose. The 3-μ region is valuable in elucidating details of structure, particularly with regard to OH, NH, NH_2, CH, CH_2 and CH_3 groups, but to make full use of this region greater resolution is required than is normally obtainable with a rocksalt prism. Between 2,800 and 1,800 cm.$^{-1}$ few important frequencies occur, so that this interval is not of great interest. At about 1,750 cm.$^{-1}$ the important carbonyl frequency occurs; but this is easily recognized and need not be included in the present scheme. Similarly, the CH_2 and CH_3 deformation frequencies at about 1,450 cm.$^{-1}$ are quite easily picked out, together with the CH_3 deformation frequency (symmetrical) at 1,375 cm.$^{-1}$; they can also be excluded.

Filing System

In order to classify bands between 650 and 1,350 cm.$^{-1}$, this region is conveniently divided into seventy 10 cm.$^{-1}$ intervals. In most cases sharp bands are available which can be measured to $\pm$ 2 cm.$^{-1}$. Band positions can be entered on punched cards, and machines are available for sorting the cards in various ways, to find a match for the spectrum of the unknown. However, even with only 100,000 cards, the sorting process would be lengthy and the necessary machines are quite costly, so that it would scarcely be possible for many laboratories to install such equipment. Fortunately, a much simpler and cheaper alternative is available. By dividing the spectra into 70 $\times$ 70 groups, each spectrum can be classified according to the positions of the strongest two bands. If the interval 650–659 cm.$^{-1}$ is called number 1, 660–669 cm.$^{-1}$ number 2, and so on to 1,340–1,350 cm.$^{-1}$, which would be designated number 70, a spectrum with its most intense band at 1,071 and its next strongest at 796 cm.$^{-1}$, for example, would be classified as 43/15.

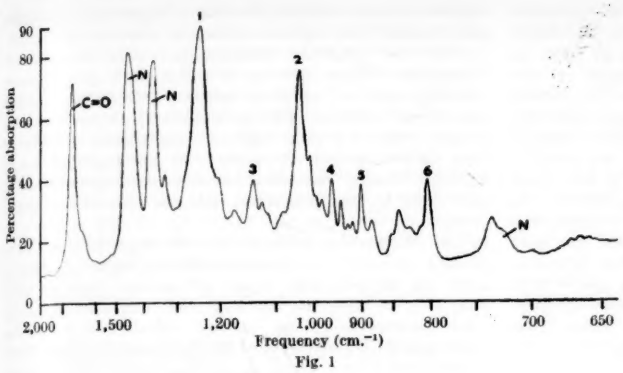

Fig. 1

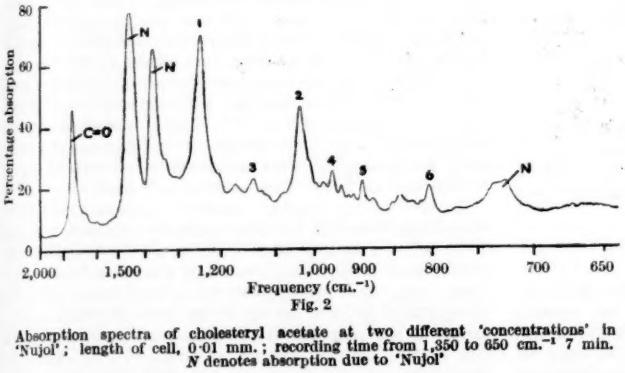

Fig. 2

Absorption spectra of cholesteryl acetate at two different 'concentrations' in 'Nujol'; length of cell, 0·01 mm.; recording time from 1,350 to 650 cm.$^{-1}$ 7 min. *N* denotes absorption due to 'Nujol'

Cards would be filed in order from 1/1, 1/2, etc., to 70/1, 70/2 . . . 70/70, and since there would be 4,900 classification numbers there would be, for a total of 500,000 compounds, something of the order of a hundred substances for each classification number.

With the details of thirty or forty compounds printed on a single card, three cards would, on an average, suffice for each classification number, and some 15,000 cards would be required for 500,000 substances. Quite a modest set of filing cabinets would house this number of cards. Once the strongest two bands have been measured in the spectrum of an unknown, it is the work of seconds to pick out the cards containing details of all compounds with their strongest two bands in the same 10 cm.$^{-1}$ intervals as in the unknown. At the worst, it is then only necessary to look through the spectral details of some hundred compounds to find one which matches the unknown.

It might be thought that the scheme as outlined so far, while possible for relatively simple substances, would fail with larger and more complicated molecules, on account of the large number of conflicting absorption bands. That this difficulty is not so serious in practice is shown by the spectrum of cholesteryl acetate, a fairly large and complex molecule (see Figs. 1 and 2). The two key bands in order of intensity are 1 and 2, while the others in order of diminishing frequency are numbered 3, 4, 5 and 6. The classification number is therefore 60/40 and the entry on the card would read :

No. of spectrum	Molecular formula	Absorption frequencies
—	$C_{29}H_{48}O_2$	1,244, 1,040, 1,138, 960, 902, 804

It is not necessary to classify the four weaker bands in order of intensity, except that when the absorption is less than 20 per cent (the strongest band corresponding to 80 per cent absorption) the frequency can conveniently be underlined to direct attention to the fact. By placing the four weaker bands in order of frequency, it becomes a simple matter, when identifying an unknown substance, to select the most distinctive band of the four and to look rapidly through all the compounds with the proper classification number to pick out any with a band in the same position. A detailed check with the remaining bands would, of course, be made to establish the identity of the two substances. If an impurity frequency happened to be chosen as the most distinctive of the four weaker bands, probably only one or two spectra at the most would have a band in the same position, and a check with the remaining bands would cause these compounds to be rejected. It would then be wise to repeat the search using another of the four bands.

In some cases it may even be possible to identify major impurities. After the bands of the main constituent have been eliminated by reference to the spectrum of the pure material, the remaining bands can be dealt with in the usual way, the strongest two being used to obtain the classification number.

Each spectrum of a known substance is given a number for the purpose of identification, and a separate index will, of course, be necessary, so that the full chemical description of the compound and classification number corresponding to a given spectrum number can be found. Conversely, if the spectral details corresponding to a known chemical compound are required, it is only necessary to look up the substance by name, obtain the classification number and then look through the cards with this number to find the desired spectral data. If more detailed information is required, recourse must be had to the original spectrum, which can easily be located once its number is known.

Some Difficulties

Of course, various difficulties could arise in putting the project into operation. For example, the spectrum of an unknown might have among its strongest bands several of similar intensity, so that the selection of the most intense and next strongest for determining the classification number is not straightforward. As an illustration, if a substance has nearly equally intense bands at frequencies denoted by *X*, *Y* and *Z*, it will be necessary to use the combinations *XY*, *YX*, *XZ*, *ZX*, *YZ* and *ZY* to exhaust all possibilities.

Yet another difficulty might be caused by one or both of the key bands of a pure substance being broad or of complex structure, so that the frequencies could not be measured with the usual accuracy. In this case the unsatisfactory bands would be discarded for the purpose of obtaining the classification number.

This should not cause much difficulty in practice, since a similar situation would arise when the same substance occurred in an unknown, and as soon as the unsatisfactory nature of one or more of the stronger bands was realized, less intense but better defined bands would be employed. Unsatisfactory bands not used for obtaining the classification number could be bracketed to distinguish them. As already mentioned, when the intensity of bands is less than 20 per cent, the frequencies would be underlined. If a band is superimposed on a continuous background of absorption, allowance should be made for this when assessing the band intensity. The simplest procedure is to take the height of a peak above any part of the immediate background free from distinct bands. Both the above-mentioned points are illustrated by the following imaginary entry :

No. of spectrum	Molecular formula	Absorption frequencies
——	——	(930), (1,387), 802, 997, 1,284, 705

The classification number would now be 16/35.

If the spectrum of the unknown has its strongest bands at, say, 801 cm.$^{-1}$ and 1,239 cm.$^{-1}$, besides looking up the cards corresponding to 800–809 and 1,230–1,239, that is, 16/59, it would be wise to look up also the classifications 15/60, 16/60 and 15/59, in case small errors have occurred in the measurement of these key frequencies.

Costs

The cost of the project as outlined, apart from the initial cost of equipment and cost of the organic substances themselves, might be expected to amount to possibly £20,000 per annum to keep ten spectrometers working continuously and to cover the cost of printing data cards. This works out at about £1 per spectrum produced for an annual output of 20,000 spectra. The cards of data could be brought up to date and redistributed as necessary each year. Each laboratory possessing an infra-red spectrometer and wishing to make use of the service would take the complete set of data cards issued each year. It is reasonable to suppose that in time at least a hundred laboratories in Great Britain alone would require the cards of data, so that an annual charge of £200 would make the project self-supporting. After only one or two years, the value of the service should be well worth this sum.

[1] Lord McGowan, "One Hundred Years of Chemistry" (Royal Institute of Chemistry : Lectures, Monographs and Reports 1951, No. 3). 3*s*. net.

COSMETICS AND DERMATITIS

At a recent meeting of the Society of Cosmetic Chemists of Great Britain, held at the St. Bride's Institute, London, a lecture on "Cosmetics and Dermatitis" was given by Dr. E. J. Moynahan, consulting dermatologist to Guy's Hospital.

Referring briefly to the history of cosmetics, Dr. Moynahan mentioned the fact that several different types of cosmetic are described in the Ebers Papyrus, and that many references to such preparations are to be found in the works of the alchemists and early herbalists. The empirical approach has continued to dominate cosmetic art and practice, however, until comparatively recent times. A noteworthy contribution to scientific study has been made by Sulzberger and others, who have begun to segregate and classify the various causes of dermatitis.

Very few primary irritants are used in modern cosmetics. Those that are found include permanent-waving reagents, which attack the keratin chemically and break down disulphide linkages ; depilatories of closely related type ; high concentrations of alkali ; and oxidation hair-dyes such as *para*-phenylenediamine. Most of the relatively few cases of dermatitis provoked by cosmetic materials are due to sensitization.

Dr. Moynahan referred to the considerable protection provided by the skin's horny layer (if intact) and its supernatant layer of sebum against the majority of external agents, with the exception of such keratolytics as strong alkalis and acids. Dermatitis, which occurs in the lower rather than keratinous layers—that is, in the living cells—varies from redness and itching to swelling, vesicle formation and finally to necrosis. Oils and predominantly oily emulsions, owing to their ability to penetrate through the lipoids of the skin, are more likely to favour the onset of dermatitis than are aqueous solutions and mainly aqueous emulsions, although factors other than the constitution of the vehicle have also to be considered. High proportions of wetting agents may lead, for example, to an undesirable concentration of active agents below the prickle cell level.

In discussing typical cases of sensitization, Dr. Moynahan pointed out that primary irritants may in turn become sensitizers. With a few notable exceptions, such as the azo dyes and amine intermediate dyes, sensitizers are unfortunately difficult to classify in chemical groups, owing to the lack of exact knowledge of the response mechanisms of the skin. It is not always easy, therefore, to predict from chemical data the tendency to irritate the skin of newly introduced chemicals. Skilfully conducted patch tests are valuable ; but, however carefully chosen be the concentration of product, size of patch and site of application, such tests have their limitations.

In a general review of cosmetics as causes of dermatitis, Dr. Moynahan said that occupational dermatitis, due to the handling of cosmetics, is comparatively rare. This may be partly attributable to the employment of automatic methods for mixing, filling and so forth. Face creams rarely give trouble except when irritant perfume materials have been incorporated in them. The same observations apply to face powders. Permanent-waving reagents give the most trouble, followed by hair dyes. Allergic dermatitis provoked by hair dyes is dramatic in character but in most cases easy to treat. In cases of lipstick dermatitis there is usually a history of exposure to ultra-violet light ; indelible dyes such as eosin are photosensitizers (as is also bergamot oil, used in eau-de-Cologne, etc.). All brands of lipstick tend to give the same reaction in such cases of idiosyncrasy. Nail-lacquer dermatitis occurs mostly on the thinly keratinized skin around the eyes and on the chin or cheek ; not on the fingers themselves. Several of the constituents of plastics have been known to act as sensitizers. A cause of nail brittleness which is more common than nail varnish solvents is the injudicious use of some of the newer detergents. Most of the anionic detergents used in cosmetics are satisfactory in the proportions normally employed : more trouble has been caused by other detergents and wetting agents used in the washing and treatment of fabrics. Rouge is virtually innocuous in character. As the keratin of hair is tougher than that of the

skin, it would appear that depilatories are bound to affect the skin keratin. For the purpose of depilation, Dr. Moynahan said that he prefers the method of electrolysis, although this method is impracticable for axillary hair removal in women. After briefly referring to cases of oil dermatitis caused by the use of 'brilliantines', he interpolated some comments on keratoplastics and then referred to the merits and defects of barrier (protective) creams. His concluding remarks dealt with the indiscriminate use of disinfectants, which can easily intensify skin irritation, and with the potential dermatitis-provoking action of highly rosined soaps.

COPENHAGEN BIOLOGICAL CONFERENCE

RECENT developments and present trends in cellular biology, physiology and chemistry formed the subject of a joint Danish–British conference held during April 30–May 2 at the Danmarks Farmaceutiske Hojskole in Copenhagen. At the invitation of Danish biologists and the University of Copenhagen, a group of research workers from Great Britain as well as several Danish scientific workers reported on the progress of their own researches, dealing with a variety of topics, which were chiefly, though not exclusively, concerned with the correlation of cell composition with specific cell functions such as growth, division and survival.

The opening session, at which the chair was taken by Dr. A. F. Hughes, began with Prof. H. G. Callan's account of his studies on the amphibian oocyte nuclei; he was followed by Dr. W. S. Bullough, who spoke on the effect of œstrogenic hormones on carbohydrate metabolism and mitosis in mouse ear epidermis; and Dr. M. Webb on the influence of certain extraneous agents, chiefly magnesium, on cell division in bacterial cultures. Dr. F. Buchthal presided at the next session, which was devoted to papers by Dr. J. M. Mitchison, on the mechanical properties of the cell surface, particularly in relation to cleavage; Dr. E. Zeuthen on nuclear growth and respiration in dividing marine eggs, in the light of his recent experiments with the refined Cartesian diver technique; and Dr. C. Waymouth on the problems of maintenance and growth of tissues *in vitro*, in a variety of media of chemically defined composition.

The chair at the next day's meeting was taken by Dr. G. H. Bourne and Prof. P. Brandt Rehberg. The proceedings were opened by Drs. E. C. Slater and K. W. Cleland, who discussed the respiratory and phosphorylative ability of heart muscle sarcosomes. Dr. S. R. Pelc and Dr. A. Howard followed with a communication on the effects of X-rays and neutrons on the synthesis of deoxyribonucleic acid in plant roots; Dr. H. Holter surveyed critically the existing methods by means of which different parts of the cell can be separated mechanically and used for studies on the localization of enzymes in the cytoplasm; Dr. R. Brown described the enzymatic changes which occur in the plant cell during growth. A much appreciated contribution was made by Prof. K. Linderstrøm-Lang, who analysed in a detailed manner the phenomena of diffusion and precipitation in Gomori's histochemical test for phosphatase. Dr. E. Hoff-Jørgensen spoke on the deoxyribonucleic acid content of some bacteria in relation to requirements for vitamin B_{12}.

Prof. J. N. Davidson took the chair on the last day of the meeting. Dr. H. Kalckar described recent experiments in which he used radioactive phosphorus for the demonstration of a pyrophosphorolysis of uridinediphosphoglucose to uridinetriphosphate and glucose-1-phosphate; Dr. R. Markham reported on some new structural characteristics of nucleic acids as revealed by the combined application of enzymic and chromatographic methods; Dr. J. A. V. Butler then spoke on the action of radiomimetic substances on nucleic acid; and Dr. C. Lutwak-Mann on the behaviour of nucleic acid in blood-forming tissues with special reference to X-ray injury.

The contributions were followed by stimulating comments and discussion, notably by Prof. C. H. Waddington, Drs. J. Ebling, J. A. Kitching, R. K. Morton and others. In conjunction with the conference three evening lectures were given. Dr. D. J. Bell reviewed the subject of "Transglycosidation: a Natural Method of Stored-energy Transfer" before the Danish Chemical Society; Dr. T. Mann spoke on "Sperm Survival and its Dependence on Metabolic Processes" to the Danish Biological Society; and Prof. J. Z. Young on "Experiments on Learning in the Octopus" to the Natural History Society.

The British party, who enjoyed initially the support of Dr. M. Swann and later of their efficient secretary, Dr. W. S. Bullough, were most cordially received and entertained by their Danish colleagues. Prof. H. V. Brønsted, Dr. H. Holter, Dr. H. Kalckar, Prof. K. Linderstrøm-Lang and Dr. E. Zeuthen spared no effort to assure for the conference the maximum of scientific and social success. A banquet at the ancient Munkekaelderen was honoured by the presence of the rector of the University of Copenhagen, Prof. H. M. Hansen.

INTERNATIONAL UNION OF BIOLOGICAL SCIENCES

MEETING OF THE EXECUTIVE COMMITTEE

THE executive committee of the International Union of Biological Sciences met in London in the rooms of the Royal Society during March 4–5. This meeting was midway between the last General Assembly of the Union at Stockholm in 1950 and the next one to be held in the summer of 1953. Thirty members of the executive committee, from eight countries, were present, representing the nine Sections of the Union, namely, those of Biometry, Botany, Experimental Cytology, Embryology, Entomology, Genetics, Limnology, Microbiology and Zoology. Some of these Sections are identified with international bodies; thus the Section of Biometry is constituted by the Biometrical Society, the Section of Experimental Cytology by the Society of Cell Biology, the Section of Microbiology by the International Association of Microbiologists, and the Sub-Section of Zoological Nomenclature by the International Commission on Zoological Nomenclature. The executive committee expressed the desire that all Sections of the Union, some of which are already affiliated to the permanent committees of International Congresses, should as far as possible be identified with international organizations having

similar activities and aims. Another wish was formally expressed that substantial financial aid be sought from international foundations for scientific establishments of the Union, in particular for the two centres of systematics and of experimentation which have been created by the Commission of the Union for Research on the Biological Control of the Pests of Plants.

The Union organizes annually a limited number of discussion symposia. In 1951 three were held on, respectively, cytochemistry, symbiosis in insects, and biometry in relation to plant growth. This year four are to be held: on the bacteriophage, at Royaumont near Paris; on cytodifferentiation and histodifferentiation, in Stockholm; on the scientific organization of botanic gardens, in London; and on the biochemical and structural bases of morphology, in Utrecht.

The International Union of Biological Sciences, which has been in existence since 1919, is a member Union of the International Council of Scientific Unions, and from time to time, as the need for them arises, joint commissions which last a few years are established between it and other Unions of the Council; for example, a new Joint Commission on Electron Microscopy with the International Union of Pure and Applied Physics has just been set up. The International Union of Biological Sciences possesses limited funds furnished by the subscriptions of its thirty-one member countries, and it acts in an advisory capacity to Unesco for expenditure by that body on biological sciences. Further information can be obtained from the general secretary of the Union, Prof. P. Vayssière, 57 Rue Cuvier, Paris.

BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

FIFTH RESEARCH PANEL MEETING

THE fifth research panel meeting of the British Gelatine and Glue Research Association was held at Beale's Restaurant, Holloway Road, London, N.7, on Tuesday, April 29, at which the total attendance of about seventy included staff of member firms, and of other research associations and government departments. The chair was taken by Mr. S. G. Hudson, chairman of the Association.

The first paper was given by Dr. J. T. Edsall, professor of biological chemistry in Harvard University and Fulbright visiting lecturer in the University of Cambridge. In his paper, entitled "The Conversion of Fibrinogen to Fibrin", Prof. Edsall commenced by underlining the striking character of the gel-forming process in blood clotting, shown all the more clearly when the purified protein constituents, thrombin and fibrinogen, are mixed in solution and a firm rigid gel is formed in a short period of time. The gel-forming ability is so great that Dr. J. D. Ferry has obtained fibrin gels at a concentration of 0·004 per cent. The two main stages in blood clotting are the formation of thrombin from prothrombin and, secondly, the thrombin–fibrinogen interaction which leads to clotting. It has proved possible to obtain purified prothrombin from which thrombin can be prepared for studies of its action on fibrinogen. Thrombin clearly acts catalytically, since the amount required to convert a substantial quantity of fibrinogen into fibrin is very small (1 part per million of fibrin). Quantitative studies of its enzyme action are, however, difficult to perform owing to adsorption of thrombin on the fibrin formed. Fibrinogen represents some 4 per cent of human plasma proteins and up to 10 per cent in beef plasma and the plasma of other animals. It has been separated by salting out or by low-temperature alcohol precipitation.

Flow birefringence, ultracentrifuge studies, diffusion and light-scattering give evidence of a molecular weight for fibrinogen of 400,000–500,000, the molecule being markedly elongated. Approximate dimensions are, for a rod-like shape, length 700 A. and diameter 38 A. Electron microscope studies by C. Hall, while confirming these figures in the main, show a considerable variation in length from molecule to molecule, and the structure appears bead-like along the length of the molecule. The sub-units may be related to observations of the action of urea in breaking down the molecule to give units of molecular weight in the region of 100,000. The molecular weight of thrombin is not known definitely, but is probably less than 100,000.

The early stages of the action of thrombin on fibrinogen have been shown by Lorand, Bailey and co-workers to involve the release of end-groups which can be estimated by Sanger's fluoro dinitrobenzene technique, giving a frequency of roughly one group per 100,000 molecular weight. In addition, 3–4 per cent of the protein weight is split off as a peptide, the composition of which is being studied. At *p*H 5 there is no evidence of clot formation when fibrinogen and thrombin are mixed. It is clear that some action occurs even in these conditions, since on raising the *p*H instantaneous clotting occurs, whereas in a mixture freshly made at the higher *p*H there is a time delay before clotting. Light-scattering indicates the formation of intermediate aggregates 2500–4000 A. long prior to setting. These aggregates are formed by the modified fibrinogen after loss of the peptide.

By appropriate choice of conditions (*p*H, salt content) the type of clot obtained can vary from a clear transparent stable gel to a doughy opaque mass easily giving rise to syneresis. The difference depends on the size of the fibrillar units, as has been confirmed by electron microscopy. The coarse clots are the basis of the fibrin films developed by J. D. Ferry and P. R. Morrison for use in neuro-surgery. The effects of *p*H, salt concentration, urea, guanidine hydrochloride, etc., on rate of clot formation have all been studied.

Electron microscope studies of the fibrils in the coarse type of clot show a periodic structure with a spacing of 230 A. reminiscent of the collagen structure. There is no ready explanation of this periodicity. The type of bonding appears to vary according to whether calcium, and a plasma component, are present or not. In the absence of these two, urea suffices to cause dispersal of the clot, but with both present it appears likely that more permanent links involving —SH groups are formed.

The second paper was given by Mr. E. Bradbury, of the British Cotton Industry Research Association, Shirley Institute, Manchester, and bore the title "The Effect of the Temperature of Preparation on the Mechanical Properties and Structure of Gelatine Films". Mr. Bradbury explained the significance of this work as fundamental to the study of the use of gelatine for rayon sizing. Gelatine films prepared by

drying at 20° C., 70 per cent relative humidity, and at 60° C., 70 per cent relative humidity, differ appreciably in their properties. Tensile tests on the films after subsequent conditioning at different relative humidities showed that those prepared at 20° C. were stronger than those prepared at 60° C. At low humidities they were also rather more extensible before rupture occurred, but at high relative humidities the 60° C. films became very extensible. At 85 per cent relative humidity their extension at rupture was 129 per cent compared with 23·8 per cent for the 20° C. films. Further experiments showed rate of drying, and the moisture content left in the film at the conclusion of drying, to be of minor importance compared with the temperature of drying. With the guidance of X-ray diffraction results, a theory has been put forward attributing the differences to differing degrees of crystallinity in the films.

The discussion on Mr. Bradbury's paper was opened by Dr. Conmar Robinson, who made use of results on optical rotation and diffusion to put forward an alternative explanation based on two configurations of the gelatin chain. The high-temperature form is presumed folded, with internal hydrogen bonding, whereas in the low-temperature form intermolecular hydrogen bonds occur. Mr. A. G. Ward described results of dilute-solution viscosity measurements on gelatin solutions at 25° C. and 10° C. There appears to be no change in shape in the isolated molecules with temperature, although a slow aggregation occurs.

The final paper was given by Mr. R. A. G. Knight, of the Forest Products Research Laboratory, Princes Risborough, with the subject "Glue Testing at Risborough". Mr. Knight outlined the development of testing procedure and made clear the basic principle of choosing test conditions related to those which the glued joints or plywood are required to withstand in practice. The importance of both plywood and glued joints for the aircraft industry during the Second World War placed great emphasis on behaviour under full exposure to the weather, since aircraft were often parked for months on end in the open. The way in which the Forest Products Research Laboratory drew on the experience of the glue-manufacturing and wood-working and -using industries was described.

MAKERERE COLLEGE: THE UNIVERSITY COLLEGE OF EAST AFRICA

IN 1922, the Uganda Government opened a technical college at Makerere, one of the royal hills of the Kabakas of Buganda just outside Kampala. In 1924 a Government medical school and teachers' training course were also started at Makerere. Gradually all trades courses at the technical college were passed over to a neighbouring institution, and agricultural and veterinary courses took their place; a school certificate course was also developed. By 1937 the College had developed a corporate life of its own and, in that year, the De la Warr Commission recommended that Makerere should develop into a centre of higher education for East Africa; this had long been the wish of the founders of Makerere. From this time the College was to cease to be a Government institution and was to possess an independent Council composed of representatives from all the East African Territories whose Governments jointly made themselves responsible for its finances*.

As secondary schools developed in other parts of East Africa, the academic standards at Makerere quickly rose and, in 1945, the Asquith Commission on Higher Education in the Colonies confirmed that the College should press forward towards university college status. In 1949 it was announced that the College had entered into special relationship with the University of London, and the way was therefore opened for degree courses at Makerere.

The path was now clear for a programme of rapid expansion. On the recommendation of the Inter-University Council for Higher Education in the Colonies, early in 1950 the British Government promised the College £1,100,000 from the Colonial Development and Welfare Fund towards a programme of building development, and the East African Governments quickly responded by guaranteeing annual grants for a five-years development scheme totalling annually approximately four times their previous contributions. The programme already embarked on aims at raising numbers in steps from the present 240 students to 630 students and some 85 members of staff by 1955. The new medical school buildings, opened by the Secretary of State for the Colonies in May 1951, are already in use. The first of the new men's halls of residence, providing accommodation for 180 students, is now complete and was occupied at the opening of the new session in March 1952. An arts faculty building and a new physics laboratory building is also about to be brought into use. A start has been made on the first new women's hall of residence, further staff houses and a science workshop. Other buildings now at the drawing or planning stage include a new chemistry laboratory building, an agriculture block, a second men's hall of residence, a library which it is hoped will provide for the eventual needs of a university of some 2,000 students, and the adaptation of a number of existing buildings to provide further accommodation for biology and satisfactory premises for an enlarged school of art.

Makerere was started for Africans, and by force of numbers it will inevitably and rightly always remain predominantly an African college. The College's Charter, however, laid it down that it was to be open to all the peoples of East Africa. In 1951 the College Council determined that with the opening of new accommodation a start should be made in this direction. It was decided that, for the coming year's entry, six places should be reserved for qualified non-Africans; in fact, an English candidate has already been offered a place for the coming year, and there are a number of Indian candidates. The one stipulation made in admitting members of all races as well as of all religious persuasions is that all should share the common residential life.

The qualification demanded for consideration for admission is the possession of the Cambridge School Certificate (Overseas) with three credits. In practice there are already many more qualified candidates for admission than can be taken. As schools develop in number and quality the matriculation standard will be raised.

The admission problem for girls is far harder than that for boys. Though Uganda and Zanzibar have full girls' secondary schools, neither the first girls'

* *Universities Review*, **24**, No. 2.

school in Kenya nor the first in Tanganyika has yet reached a School Certificate form, though both are due to do so within the next two years. Meanwhile, only a few girls have qualified for matriculation through predominantly boys' schools. Most of the women accepted for Makerere under "Special Entry" conditions have had some years teaching experience in primary schools, and, though they often find it a hard struggle to survive academically, some of them develop during their life at the College a hitherto hidden maturity. The whole question of the College's contribution to women's education is at present being studied with the help of an advisory committee of persons engaged in this sphere in the territories.

Like the sister Colonial university colleges, Makerere is in special relationship with the University of London so far as its courses for the B.A. and B.Sc. degrees are concerned. The College takes the initiative in putting forward its own proposals for syllabuses which it submits to the relevant Boards of Study of the University. The process of negotiation up to the final stages is carried through informally between opposite numbers. Similarly, the College examiners submit the first drafts of the Intermediate and Final degree papers and do the first marking of the scripts, which are then sent by air mail to the University of London examiners for the final determination of results. It is too soon to assess the full potentialities of the scheme.

If Makerere is to serve East Africa's needs as a university it will also have to become a centre of research. A start has been made. There are two research schemes for which the College has taken responsibility but which are separately financed from Colonial Development funds—the East African Institute of Social Research under the directorship of Dr. Audrey Richards, and a scheme to investigate malnutrition and anæmia under Prof. Eric Holmes, the head of the College's physiology department.

The most critical problem at Makerere is the recruitment of staff. Not only will Makerere have to find men and women with the necessary specialized qualifications to teach at university-level, but among them those who are willing to offer their experience and skill and adapt them to the teaching problems and the opportunities of an African university college.

STATISTICS FOR COLONIAL AGRICULTURE

IN January 1947 the Agricultural Economics Research Institute of the University of Oxford was asked to undertake a review of the organization and methodology of agricultural statistics in Colonial territories, in the light of reports received from the various Colonial Administrations.

The report, prepared by Mr. K. E. Hunt of the Institute*, opens with a useful selection of statistical series for first study, followed by a programme, in broad outline, for obtaining such data, first of all on a small (village) scale, with later developments either more intensive or more extensive. The first section concludes with a suggested set of definitions of terms used in agricultural statistics. Succeeding sections deal in more detail with techniques appropriate to the various kinds of information sought. A glance at the 'contents' gives some idea of the comprehensive nature of the review. There are sections on village studies (3), extensive surveys (4), crop yield and production estimation (7), crop production forecasting (8), mixed crops (9), tree crops (10), land utilization (11), livestock populations and output (12), and two sections on marketing and distribution. With the more intractable problems of the later sections, the detail is naturally less. Under these headings many other important practical topics, such as recording technique, approach to selected communities, sample selection, correction of bias in eye estimation, crop cutting techniques, etc., are discussed.

Various methods and the results of much valuable experience both in office and field—in preparation, planning, inauguration, execution, analysis and reporting—are thus brought together. By clearly defining the main features in each of these situations, whether difficulties, possible approaches or points to consider, and including actual examples, the report makes most informative and stimulating reading. Many suggestions will need but slight modification to suit the locality. Matters, more of experience than principle, such as preparation of schedules and questionnaires, measuring areas, tabulation, analysis and records are dealt with in the appendixes.

The extremes of excessive detail but limited application and of discussions in abstract general terms are alike avoided; instead, principles are described in homely terms, statistical refinements not being considered necessary at the present. This publication will surely do much to satisfy a long-felt need.

G. E. Hodnett

* Statistics for Colonial Agriculture—Report on the Organisation of Recording and Estimating. Colonial Research Publications No. 11. H.M.S.O.) 7s. 6d. net.

ABORIGINAL RAIN-MAKERS

IN many parts of Australia droughts have an appalling effect upon the sources of food of an aboriginal tribe, and it is not surprising to know that both the black and the white man have sought to stimulate Nature to greater generosity with her life-giving rains. The ways in which they seek to induce rain are described by Frederick D. McCarthy in the *Australian Museum Magazine* (10, No. 8).

The aborigines desire rain at specific times both for individual and for group or collective purposes. A man attempts to create a storm or shower to obliterate footsteps when eloping with a woman, or, if he is a criminal, escaping the vengeance of his victim's friends. The making of rain, however, becomes a serious matter when it is organized by a local group whose reason may be the overwhelming one of survival in a drought-stricken land, or the desire to carry out important seasonal ceremonies upon which the life-giving power of the community depends; a local group may wish to punish another one by sending storms to spoil their hunting and fishing.

The rites are usually performed during the day; but the Yaroinga of Queensland have one method in which special songs are sung during the night. The rain-maker uses his deep knowledge of local weather conditions as a guide and performs his rites in seasons and at times when rain can reasonably be expected; as a result his efforts are often rewarded with success. In many tribes the rites may be performed by any individual; but as a rule there are

one or more rain-makers in a local group who either confine their magical activities to this sphere or are fully initiated medicine-men. In most tribes women cannot witness the rites; in others they participate in some methods or perform a simple type of magical act themselves.

The methods employed by the rain-makers are surprisingly varied, originating as they do in a dream, as a traditional rite performed by the dream-people, or from an incident in daily life which has been followed by rain. Many of the methods are imitative of clouds and falling rain, and of aquatic animals; others seek to persuade the ancestral beings to release the rain, and some medicine-men believe they can go up to the sky to open the clouds.

The Dieri and other tribes of the Lake Eyre district believe that the mura-mura, their spiritual ancestors who made and inhabited the earth in the dream-time prior to man's occupation, now live in the sky, and some of them have to be influenced by ceremonies to release the rain from the clouds.

In south-east Australia storms of wind and rain, and also floods, were believed to be sent by enemies to disturb hunting and fishing activities. The Kurnai of Gippsland squirted water from the mouth in the direction from which rain usually came, and sang magical rain chants acquired in dreams by both men and women.

In Arnhem Land pounded bark (used for poisoning fish) is wrapped in grass, weighted in stones, and taken out into either salt or fresh water by a man until his shoulders are covered; here he drops the bundle, sings a song about falling rain, and pushes the water with his hands to represent the rain splashing on its surface. He expects the clouds to form in about three days and the rain to come on the fourth day after this rite. Here, too, a large bundle of green grass fashioned into a human image is buried and when it swells up rain is expected to fall. The rain is stopped by taking the grass out of the water or ground and spreading it out to dry.

AIR MASS CLIMATOLOGY OF THE BRITISH ISLES

SOME simple facts about the air mass climatology of the British Isles, such as the difference between the relative coldness of east and the relative warmth of south-west winds in winter, have been common knowledge for ages. In the second and third decades of this century the Norwegian school of meteorologists, led by V. and J. Bjerknes, elaborated the ideas of Shaw, Lempfert and others to depict the atmosphere as 'organized' not only into cyclonic and anticyclonic systems but also into warm and cold air masses (often referred to respectively as tropical and polar air) with different life-histories. The interplay of different air masses was shown to produce the day-to-day weather changes of the temperate and polar regions.

In a recent Air Ministry/Meteorological Office* memoir, which is a contribution to synoptic climatology, Dr. J. E. Belasco has investigated the more important physical properties of the atmosphere over the British Isles in twenty-one subdivisions of tropical and polar air, using surface and upper-air data for the period 1931–45. The generalized tracks over which the air masses reach the British Isles are shown by maps, and the frequency of occurrence of the air masses and the average temperature and humidity of the atmosphere in them at the surface at Kew Observatory and in the upper air up to 450 mb. (about 6 km.) over the British Isles are set out in tables and thermodynamic diagrams. There is also a discussion of the changes of temperature and humidity which maritime tropical and direct polar air masses undergo as, on their way to the British Isles, they pass over a surface respectively colder and warmer than their lowest layers. With the aid of this memoir, it has now become possible for the first time to explain some aspects of the climate of the British Isles in terms of the incidence and of the physical properties of different air masses instead of describing them statistically by the usual presentation of means and extremes.

The discussion shows that the correspondence between air mass and wind direction is quite rough and far from unique. Thus, north-west winds usually bring a cold air mass with a large fall of temperature with height and associated showery weather; but when an anticyclone remains stationary westward of Ireland, such winds can bring air originating over the sub-tropical Atlantic which has been cooled from below on its way. Again, polar air of a particularly unstable type can come with a south wind having travelled around a stationary depression centred south-west of Ireland. Quite the coldest air mass is, as is well known, the one which comes in winter from Russia and reaches the British Isles from the east or south-east. This air mass has in January a mean maximum temperature of 31° F. at Kew. The warmest air mass in January comes from the Madeira area and has a mean maximum of 53° F. at Kew. In July the temperature differences between the coldest and warmest air masses are nearly as great as in January. Air of west Mediterranean origin has at Kew in July a mean maximum of 82° F. and air direct from the sea north of Norway a mean maximum of 64°. The differences of temperature between air masses in the upper air are larger than at the surface because the primary heating and cooling occur at the surface.

Dr. Belasco's memoir will be of value not only to those seeking a physical explanation of British climate, but also to the weather forecaster in stating the weather to be expected in an air mass the arrival of which he has foretold.

* Air Ministry: Meteorological Office. Geophysical Memoir No. 87: Characteristics of Air Masses over the British Isles (M.O. 530*b*). By Dr. J. E. Belasco. Pp. 34. (London: H.M.S.O., 1952.) 2*s*. 6*d*. net.

PAPER PULP RESEARCH AT THE DEHRA DUN RESEARCH INSTITUTE

INVESTIGATIONS on the pulping of *illuk* grass (*Imperata arundinacea*) by the soda and the mono-sulphite processes* have been undertaken at the Forest Research Institute, Dehra Dun, at the request of the Ceylon Government, which forwarded samples for the purpose, with the view of ascertaining the respective economics and suitability of the two

* Indian Forest Bulletin No. 145: Pulping of Illuk Grass (*Imperata arundinacea*) by Soda and Mono-Sulphite Processes. By Chattar Singh and Dr. S. R. D. Guha. Pp. ii+10. (Delhi: Manager of Publications, 1951.) Annas 8; 9*d*.

processes to the species. Research has shown that the cost of chemicals required for pulping the grass by the mono-sulphite process is 38 per cent more than that required by the soda process. Of the two methods of digestion, namely, 'overhead' and 'fractional', as applicable to the soda process, the 'fractional' method of digestion appears to be more suitable, as well as more economical, for pulping of *illuk* grass.

In Indian Forest Leaflet No. 124 of the Research Institute*, R. V. Bhat and N. S. Jaspal discuss investigations on pulps for writing and printing papers from the castor oil plant (*Ricinus communis*). In India, so far, bamboo and *sabai* grass (*Eulaliopsis binata*) are the chief raw materials used in the paper industry. The local supplies of these materials are insufficient to meet the requirements of the existing mills. Bamboos are used in India for a large variety of other purposes, and the *sabai* grass only grows in particular areas. The production of paper in Indian mills in 1949 amounted to 170,000 tons. To meet domestic demands for paper, a large quantity is annually imported, and these demands are increasing. The instalment of further new pulp plants depends upon larger amounts of raw material being available.

Reimold had advocated the cultivation of the castor oil plant in America, as a high-grade cellulose could be produced at a low price owing to the cheapness of the raw material. The castor oil plant is commonly grown as an annual crop in several parts of India for its seeds, from which the oil is obtained, and it is upon the stalks, for the purpose of making pulp, that experiments were made at Dehra Dun. The plant is also grown as a perennial small tree, and this, too, was the subject of research work.

The conclusions arrived at are as follows. Easy-bleaching pulps with satisfactory strength properties can be prepared from stems of castor oil plants by the soda and the sulphite processes, the latter being the more suitable. The stems of the annual and the perennial varieties can be used for pulping without the removal of the bark. The pulps from the wood are short-fibred, whereas those from the bark are long-fibred. Owing to this, pilot-plant experiments will have to be carried out to determine whether these pulps can be used as such for the production of writing and printing papers or whether they must be mixed with long-fibred pulps such as those from bamboos and *sabai* grass. Since in India the castor oil plant is grown for its seeds and oil production, it is considered that the stalks should be available at a cheap rate.

* Indian Forest Leaflet No. 124: Indigenous Cellulosic Raw Materials for the Production of Pulp, Paper and Board. Part 2: Pulps for Writing and Printing Papers from the Castor Oil Plant *Ricinus communis*. By Dr. R. V. Bhat and Narendra S. Jaspal. Pp. ii+15. (Delhi: Manager of Publications, 1951.) Annas 8: 9*d*.

ORNITHOLOGY IN THE U.S.S.R.

THE ornithology of the U.S.S.R. has been somewhat imperfectly known in other countries, especially of recent years. On behalf of the British Ornithologists' Union, Dr. Hans Johansen, formerly professor in the University of Tomsk and now of the Zoological Museum, Copenhagen, has prepared a paper which attempts to review the place of ornithological studies in the U.S.S.R. to-day (*Ibis*, **94**, No. 1). Johansen's task has not been easy because no journal devoted entirely to ornithology has been published in the U.S.S.R.; some of the publications containing ornithological articles are unobtainable. Information about articles on ornithology can frequently only be obtained through lists of Russian literature, so that the articles cannot be seen or judged on merit. Although Johansen's survey must, therefore, necessarily be regarded as incomplete, the author is to be commended for undertaking a task which has involved consideration of not less than five hundred publications.

A summary of Johansen's article indicates that the old traditions of Russian ornithology were best and most strongly represented by faunistic reviews which have almost completely surveyed the whole of the enormous country. Large amounts of material were collected in the form of bird-skins, which made possible the systematic revision of many groups of birds. This again made possible broad concepts of the avifauna of the U.S.S.R. as a whole and the numerous zoogeographical and historical faunistic descriptions.

In addition to these old branches of work, new problems have arisen in recent times, as in the rest of the world. Of these, biological and ecological subjects are prominent and, among other things, have led to the production of ecological-geographical monographs on the birds of Russia.

Many investigations have also been made into the problems of bird migration; in addition to ringing and field observations, laboratory experiments have been made, with good results.

Some work has been done on anatomy and physiology in which attempts were made to connect them with biology, ecology and systematics. Investigations on parasites as well as the disadvantages and benefits of birds to forestry and agriculture were specially supported by the authorities.

If the accomplishments of the Russian ornithologists are considered from a wider and more international point of view it can be said that, on the whole, development has proceeded on the same lines as in other countries, though studies naturally show the peculiar influence of the country.

Because of the great extent of the country, from the Baltic to the Pacific Ocean and from high polar latitude to the subtropical conditions in the Transcaucasus, Russian ornithologists have done little work outside their own country. There is, however, the work of Zarudny in Persia and the numerous Russian expeditions made long ago in Mongolia and central Asia. In recent times these works were continued by Sushkin, Tugarinov, Sudilovskaia (Kashgaria) and, more especially, by Madame Kozlova.

The extent and variation of the U.S.S.R. have also been the reason why the so-called line of faunistic research has received special attention. In recent times, according to Russian information, the emphasis has shifted to ecological-geographical characteristics of entire taxonomic groups of birds. This can be regarded as a new branch of Russian ornithology, though publications have not been received in other countries.

Another speciality of Russian ornithology, which was started by Nikolai Severtzov so long ago as 1877, is the profound zoogeographical analysis, which was chiefly combined with historical conclusions. Of the latest achievements, Stegmann's work on the ornithogeographical division of the Palæarctic Region can claim originality, since he provides new methods and techniques of zoogeographical description.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Interference Microspectroscopy

ONE of the main advantages of interference microscopy over phase-contrast microscopy as normally practised is that certain forms can be used for the quantitative determination of the phase change or optical path difference introduced by the object[1]. Not all types of interference microscope, however, are equally suitable for quantitative work, as the phase difference between the interfering beams cannot always be varied continuously. It is therefore useful to have an alternative method of measuring the phase change.

It is well known that, if light from an interferometer system is viewed through a spectroscope, a series of dark bands can be seen crossing the spectrum when a source of continuous radiation is used. When the phase difference between the interfering beams is uniform throughout the field of view these dark bands are straight; but when additional path differences are introduced, as by a refractile object, the bands become displaced and distorted in a manner related to the phase change produced by the object. Thus, if the image of a transparent object such as a cell is projected through an interference microscope on to the entrance slit of a spectrograph, the displacement of the dark bands gives a convenient method of determining the phase change produced at each point of the object the image of which is formed along the slit.

The technique used is similar to that described elsewhere for ultra-violet absorption microspectroscopy[2]. The measurement of the phase change in the object can be applied to the determination of mass as recently described[3]. An unexpected advantage of the method is that the contrast of the bands seen in the spectrograph is much greater than that of the interference fringes in the field of view. Indeed, this type of method is often used for demonstrating the presence of interference effects which may be suspected but cannot be otherwise detected. This is particularly the case when white light is used and when the path difference between the interfering beams is great. The accompanying photograph illustrates this point. The object was an unstained human oral epithelial cell, mounted in water between a semi-rhodiumized slide and coverslip, as suggested by Merton[4]. A tungsten filament lamp was used as source and the separation between slide and coverslip was rather large. The full illuminating aperture of the condenser was used. In these circumstances, no interference fringes whatsoever could be seen in the field of view and the object, being transparent, was virtually invisible. Fringes were quite easily seen in the spectrograph, however, and their contrast could be enhanced photographically without loss of detail.

Interference microspectrograph of epithelial cell, in visible region, taken under conditions of zero contrast in field of view of microscope

We thus have the possibility of obtaining precise optical information concerning an object which cannot be seen under the microscope. Moreover, since the full illuminating aperture is used, the resolving power of the microscope itself is high. The contrast, which may be very low or even zero in the microscope, can be largely recovered in the spectrograph. If the apparatus is adjusted to give good fringes and high contrast in the microscope field of view, the contrast in the spectrograph is very much better than that shown. It is not essential to use a tungsten filament lamp, as most high-pressure mercury lamps emit sufficient continuous radiation between the spectral lines to enable the dark bands to be seen. Such lamps are generally preferable for visual work.

If the object contains absorbing material, anomalous dispersion may occur in the region of absorption bands, so that the refractile and absorbing properties may be simultaneously observed. Finally, at those points which introduce zero phase change, the refractive index will be equal to that of the mounting medium at the same wave-length.

I wish to acknowledge the help received as Johnston, Lawrence and Moseley Research Fellow of the Royal Society.

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[1] Dyson, J., *Proc. Roy. Soc.*, A, **204**, 170 (1950).
[2] Barer, R., Holliday, E. R., and Jope, E. M., *Biochim. Biophys. Acta*, **6**, 123 (1950). Barer, R., in "Cytology and Cell Physiology" (edit. G. H. Bourne, 2nd edit., Clarendon Press, Oxford, 1951).
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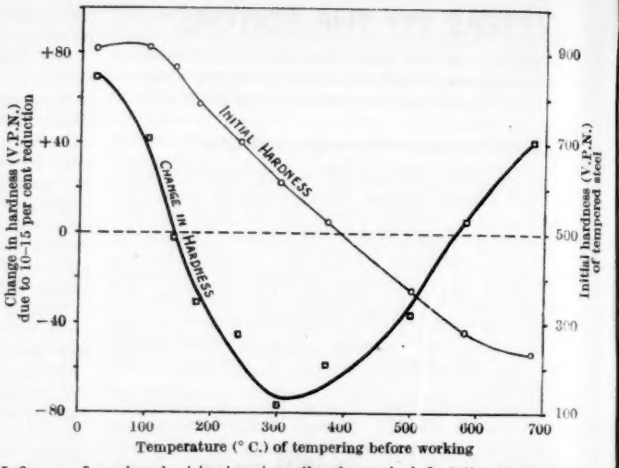
Thermal Measurements on Small Transient Systems

EXPERIMENTS recently carried out in this laboratory have shown that it is practicable to heat the wires of a thermocouple by the passage of an electric current and at the same time to record the temperature of the junction by means of the thermo-E.M.F. A high-frequency current is used in order that the concomitant voltage (order 10 volts) may be separated from the thermo-E.M.F. (order 0·001 volts) by means of inductance-capacitance filters. The apparatus can be used for measuring the thermal constants of poor conductors placed in contact with the couple wires.

It has been found convenient to pass a pulse of current (after which the system returns to its original state) and to make deductions from the E.M.F.-time record obtained during the heating period. If the pulse is long enough for a steady state to be achieved, the highest temperature is inversely proportional to the thermal conductivity; otherwise both conductivity and specific heat have to be considered. Calculations made by Dr. S. Paterson and Miss Jean

Substance with which wire was in contact	Proportion of energy retained by wire after 96 msec.	
	Observed	Calculated
Medicinal paraffin	0·57	0·52
Castor oil	0·48	0·48
Glycerol	0·35	0·38
Water	0·19	0·22

Davidson have shown that it is in principle possible to calculate absolute values of these quantities from a single record. In practice it has not been yet possible to do this, because available couples are not perfect cylinders; comparison with theory has shown that they behave in this work as though they are 50–100 per cent larger than the nominal diameter of the wire. Nevertheless, measurements made relatively either to the original state of a given system or to a system having well-established properties have been possible. The precision of these measurements is indicated by the accompanying table, in which calculated and observed values of the energy retained by the wire after being heated at a steady rate for a chosen time are compared. In obtaining these figures the values for castor oil have been made to agree by an arbitrary adjustment equivalent to the assumption that the wire is 1·64 times its nominal diameter. The time chosen is such that both thermal conductivity and specific heat play an important part in determining the results.



Influence of previous heat-treatment on the change in indentation hardness due to 10–15 per cent reduction in height by compression. 0·88 per cent carbon steel, water-quenched from 800° C., immediately cooled in liquid oxygen, and then tempered at the temperatures indicated for 2 hr., before deformation. Hardness values represent the mean of 12 readings taken within 2 hr. of straining. (Increase in hardness of specimens tempered below 140° C. may be under-estimated due to local cracking)

The method has advantages over conventional methods, notably in speed and in the minimum size of the system on which measurements are practicable: with, for example, 40 S.W.G. wires, which are not inconveniently fine, a measurement takes only 100 msec. and the system need be only 1·0 cm. long by 0·1 cm. in diameter. Moreover, because the average temperature need not be controlled for long periods, measurements at elevated temperatures offer no particular difficulties. The method is therefore very suitable for studying small transient systems such as exist in the reaction zones of thermal self-propagating reactions; it is at present being used for measuring how much the thermal conductivity changes when reaction is propagated in mixtures of iron and potassium permanganate[1].

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[1] Hill, R. A. W., Sutton, L. E., Temple, R. B., and White, A., *Research*, **3**, 569 (1950).

Magnetic Properties, Internal Strains and the Bauschinger Effect in Metals

Polakowski[1] has recently drawn some general conclusions about the behaviour of metals during reversed deformation, and has suggested that the influence of reversed straining on certain properties, including intensity of magnetization, may be predicted on this basis. Since not all changes which may result from plastic deformation are associated with reversible internal strains, however, the behaviour of a change of unknown cause cannot be predicted. On the other hand, if it be concluded on the basis of experiment[2] that the change in the Curie temperature of cementite in cold-worked steels is directly related to the textural stresses set up between the cementite and ferrite, then it may be expected that this effect will give a more certain indication of magnitude of strain in the cementite particles of a steel than can be derived from hardness tests.

In this connexion I suggest that, in order to understand the mechanism of the work-softening effects discussed by Polakowski, it will be necessary to consider the nature of the textural stress systems present in the different materials. In the case of the softening observed in hardened and tempered steels after moderate degrees of cold-working, for example, a textural stress system which is effectively isotropic on a macroscopic scale is partially replaced by a directional system and, in general, the reduction in indentation hardness is not accompanied by any softening in the direction of working.

The extent of 'work-softening' effects may depend not only on the intensity and directional characteristics of the initial textural stress patterns but also on their scale.

The accompanying diagram summarizes results showing that, in the case of a heat-treated 0·88 per cent carbon steel, the change in indentation hardness which results from a moderate degree of deformation is dependent on the microstructure (approximately the reductions were those which cause the maximum degree of 'work-softening'). Up to a certain limit, about 600 Vickers Pyramid numeral in this case, with increasing initial hardness the magnitude of the softening effect increases progressively. At higher hardness values, however, the observed softening is less, although the initial internal strain energy will continue to increase with hardness. Martensite tempered below about 140° C. does not show the softening effect. Probably rather similar patterns of behaviour are shown by certain age-hardening alloys.

A possible explanation of these effects may be visualized in terms of the suggested influence of the scale of the internal stress pattern on the movement of dislocations in solid solutions and duplex alloys[3]. When the separation of particles of the precipitate is sufficient to allow the formation of dislocation loops around individual particles, then the initial internal stress pattern may be greatly modified as a result of plastic deformation, and indentation tests may in-

dicate abnormally low rates of work-hardening during the early stages of deformation.

However, it is possible that the behaviour of steel, which shows marked strain age-hardening effects, may be complicated by the influence of carbon atoms associated with the ferrite.

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Jan. 30.

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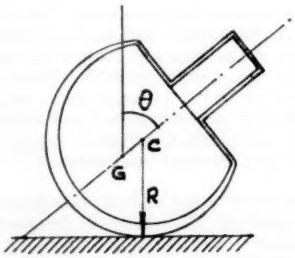
The Symmetrical Spherical Top

A top with a cross-section as shown in the accompanying diagram exhibits, when spinning on a horizontal plane, a surprising effect: the stem, which originally points upward, moves away from the vertical while continuing to rotate about this direction, until it touches the supporting plane; whereupon the top quickly rises on the stem and continues its rotation in this stable position. A similar behaviour is shown by a sphere consisting of two halves of different specific weight. If the initial angular velocity is large enough, the centre of gravity will rise until it reaches the highest position possible, the sphere then rotating about its axis of symmetry.



It is possible to show[1] that this effect is due to the friction arising when the point of contact slides over the supporting plane. The torque resulting from this force causes the angular momentum vector to move over the surface of a cone with vertical axis. Thus the angular momentum will have a component perpendicular to the plane through the vertical and the axis of symmetry, which effects a change of the angle θ between these two lines. In this way the following two effects can be described:

(1) If the centre of gravity, G, lies eccentrically in a sphere with axially symmetric distribution of mass, while the moments of inertia about the axis of symmetry and another axis through G perpendicular to the former are equal, the rotation will be stable if the position of G is as high as possible.

(2) If G coincides with the centre, C, of the sphere, while the moment of inertia, A, about the axis of symmetry differs from that, B, about an axis through G perpendicular to the former, stable rotation will be about the axis with the greatest moment of inertia.

The two effects can combine with different results, all of which are characterized by the vanishing of the sliding motion of the point of contact.

(3) If G is eccentric and $A \neq B$, the stable equilibrium value of θ is:

$$\theta = 0 \text{ or } \theta = \pi \quad \text{if } \frac{A-B}{A} > \frac{GC}{R},$$

$$\theta = \pi \quad \text{if } -\frac{GC}{R} < \frac{A-B}{A} < \frac{GC}{R},$$

$$\cos\theta = \frac{GC}{R}\cdot\frac{A}{B-A} \quad \text{if } \frac{A-B}{A} < -\frac{GC}{R}.$$

The value of θ given for the latter case is an approximation which is valid at high rotational energy.

A homogeneous sphere with a cavity near a point of the surface is an example of the first case of (3), the sphere with the two halves mentioned above of the second one. An example of the third case of (3) is a sphere, which except for a concentration of mass near a point of the surface, is of homogeneous density. The top shown in the diagram—commercially available in Holland under the names "tippetop" and "toupie magique"—is of the same type. However, before the equilibrium value of θ is reached the stem will touch the supporting plane. The effect due to the eccentricity of G is strengthened then and the top rises on the stem.

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Tanning of Fatty Acid and Protein Monolayers by Metal Ions (Cr, Al, Fe and Cu)

It has been shown by Wolstenholme and Schulman[1,2] that metal ions such as Fe, Al, Co, Cu interact with fatty acid monolayers over the *p*H stability range of the basic metal ions. There were indications that the association could be influenced also by the size and shape of both the fatty acid molecule and the basic metal ionic unit. The present communication shows how these ideas can be applied to the chromium ionic system, together with a direct analogy between the interaction of the basic chromium ion, with fatty acid monolayers, and the tanning of a protein monolayer. Here, the reactivity of the carboxyl group is important in both systems.

It can be readily shown that a chromic acetate solution does not react with long-chain amine monolayers, since there are no basic chromium ions avail-

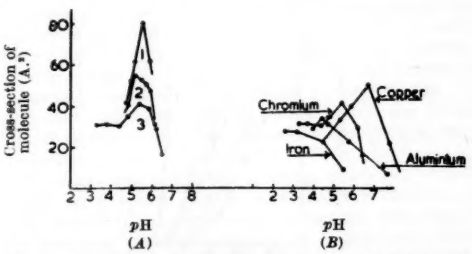

Fig. 1. (*A*) Effect of *M*/2,000 chrome alum on fatty acids. (1) 4:10 fatty acid $C_{10}H_{21}.CHCOOH$ (C_4H_9) (cross-sectional area 46 A.²); (2) 1:12 fatty acid $C_{12}H_{25}CHCOOH$ (CH_3) (cross-sectional area 30 A.²); (3) myristic acid $C_{13}H_{28}CH_2COOH$ (cross-sectional area 20 A.²). (*B*) Effect of *p*H on area of solidification—myristic acid

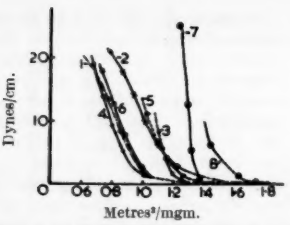

Fig. 2. Bovine albumin films: (1) *p*H 3·8, *M*/100 sodium sulphate, 21° C.; (2) *p*H 2·38, *M*/100 ferric chloride, 21° C. (2 hr.); (3) *p*H 2·86, *M*/100 ferric chloride and *M*/110 sodium sulphate, 21° C. (1½ hr.); (4) *p*H 4·2, *M*/100 aluminium chloride, 21° C. (1 hr.); (5) *p*H 4·4, *M*/100 aluminium chloride and *M*/10 sodium sulphate, 20·5° C. (1 hr.); (6) *p*H 5·52, *M*/100 copper sulphate, 20° C.; (7) *p*H 5·26, *M*/2,000 chrome alum, 18·5° C. (1 hr.); (8) *p*H 7·15, phosphate buffer and tannic acid, 80 mgm./l., rigid unstable film after 1½ hr.

able over the *p*H range in which the amine is associated. Strong interaction takes place with the carboxyl group in fatty acids over the *p*H range in which the di-basic chromium ion exists. This reaction is shown by the change in the area of the solidification of the molecules and the mechanical properties of the fatty acid monolayers on the metal salt solution. These results are summarized in Fig. 1.

Fig. 1,*A* shows how the basic chromium ionic unit can expand to accommodate the increasing size of the fatty acid molecule (that is, from 40 A.² to 80 A.²). This property of the interlinking basic ionic aggregates appears to be greatest with copper, and decreases in the following order[2]:

$$Cu^{++} > Cr^{+++} > Al^{+++} > Fe^{+++} > Co^{++},$$

as shown in Fig. 1,*B* (for myristic acid monolayers).

These results on solidification of fatty acid monolayers by the basic metal ion can be applied to the tanning of protein monolayers. Fig. 2 shows how the rigidity and expansion of the protein monolayer is affected by the basic metal ions, over the same optimum *p*H range as in the tanning of the fatty acid monolayers. It appears that there is a potential barrier[3] to be overcome by the adsorbing basic metal ion aggregate, due to the positively charged amine group in the protein monolayer. This barrier can be readily overcome by the addition of sulphate ions. This tanning process works well with iron, aluminium and chromium salts, but curiously, not at all with copper. A tannic acid or vegetable tanning[4] of the protein monolayer is given as a comparison. In this case, the amine groups in the protein monolayer are interlinked by the phenolic groups on the tannic acid molecule.

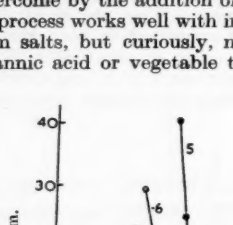

Fig. 3. Bovine albumin films: (*A*) *p*H 3·8, *M*/100 sodium sulphate, 18° C.; (1) *p*H 2·1, *M*/2,000 chrome alum, 18° C. (1 hr.); (2) *p*H 3·7, *M*/2,000 chrome alum, 20° C. (1 hr.); (3) *p*H 4·21, *M*/2,000 chrome alum, 17·5° C. (1 hr.); (4) *p*H 4·76, *M*/2,000 chrome alum, 18·5° C. (1 hr.); (5) *p*H 5·26, *M*/2,000 chrome alum, 18·5° C. (1 hr.); (6) *p*H 5·71, *M*/2,000 chrome alum, 17·5° C. (1 hr.); (7) *p*H 6·07, *M*/2,000 chrome alum, 18·5° C. (1 hr.)

Fig. 3 shows the complete tanning of bovine albumin monolayers with chrome alum solutions over a *p*H range which gives a direct analogy with the tanning of fatty acid monolayers.

As was found by Wolstenholme and Schulman[1], minerals containing chromium can be floated by soluble fatty acids over the *p*H range where the fatty acid monolayers are made insoluble by the basic chromium ions, giving an identical optimum *p*H range. This shows that chromium ions are available on the mineral surface and form a monolayer network of fatty acid – basic chromium ionic complex, which is hydrophobic.

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A Possible Source of Artefacts in the Chromatography of Tissue Extracts containing Inorganic Iodide

Unknown substances containing iodine, apparently associated with inorganic iodide, have been detected in the plasma of patients who had previously received therapeutic doses of radioiodide[1,2]. These substances were discovered by chromatographic separation of the radioactivity present in butanol extracts. The methods of preparation involved paper chromatography with acid solvents[1] and extraction of acidified plasma[2].

Acidification of solutions of inorganic iodide is known to cause the liberation of elementary iodine, and we decided to test the possibility that iodination of unsaturated compounds present in the starting material might take place during extraction and chromatography in acid solutions. Preliminary work on pure substances was clearly desirable; and this communication describes experiments with cholesterol, cholesteryl oleate and triolein, using the radioactive isotope, iodine-131.

0·5 c.c. of a solution of sodium iodide-131 containing 3·5 μC./c.c. was added to 2 c.c. of an acidified aqueous suspension of the lipoid. The suspensions were extracted three times with 5 c.c. of water-saturated *n*-butanol, the layers being separated by centrifugation, and the butanol extracts were evaporated to dryness under reduced pressure on a boiling water-bath. The residues were each taken up in 0·5 c.c. of *n*-butanol. 1-μl. aliquots of the resulting solutions were placed on filter paper strips 2 cm. wide (Whatman No. 1) and chromatographed by the descending method in *n*-butanol/dioxane/2*N* ammonia, prepared according to Gross *et al.*[3]. The butanol extract of an acidified solution of sodium iodide-131 alone was prepared and chromatographed directly with, and without, the addition of lipoid in ether solution to the spots. For these latter experiments *n*-butanol/dioxane/2*N* ammonia and *n*-butanol/

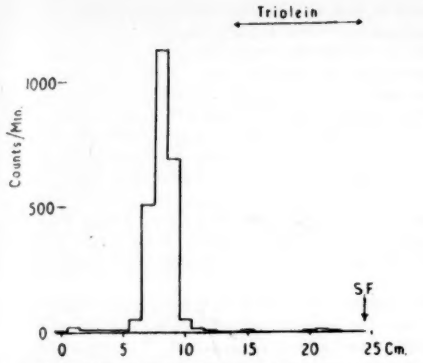

Fig. 1. Distribution of radioiodine on a filter paper strip after chromatography of sodium iodide-131 and added triolein in *n*-butanol/dioxane/2*N* ammonia. (*S.F.*, solvent front)

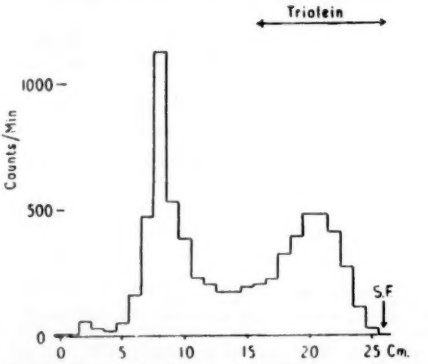

Fig. 2. Distribution of radioiodine on a filter paper strip after chromatography of the butanol extract prepared from an acidified aqueous suspension of triolein to which sodium iodide-131 had been added. (*S.F.*, solvent front)

2*N* formic acid (Gross *et al.*[3]) were used as developing solvents in different runs. The lipoids were detected by their fluorescence in ultra-violet light. They formed bands or streaks extending behind the solvent front for distances depending on the amount added to the paper. The radioactivity of each 1-cm. length of the strips was measured separately by means of a Geiger counter fitted with a lead diaphragm. Five-minute counts were made in each position.

Solutions of radioiodide alone, with or without previous butanol extraction, showed one peak of radioactivity ($R_F = 0{\cdot}33$) after chromatography in butanol/dioxane/ammonia. In butanol/formic acid, the R_F of radioiodide was found to be 0·25, but there was some 'tailing' of the spot. In the latter solvent, there was also a small subsidiary peak, the R_F of which was 0·9, representing about 0·5 per cent of the total radioactivity on the paper.

In the case of solutions containing both lipoid and radioiodide, only one large peak of radioactivity was present if iodination did not occur (see Fig. 1). Iodination caused a second peak to appear in the same position on the paper as the fatty substance (see Fig. 2). Fig. 2 demonstrates iodination during extraction from an acidified suspension. Iodination during chromatography with butanol/formic acid gave rise to a similar picture.

No iodination of any of the three lipoids took place during chromatography in alkaline conditions. Cholesterol itself was not detectably iodinated during chromatography in acid conditions and was found to have taken up only 3 per cent of the added radioiodine in the course of extraction from an acidified suspension. Cholesteryl oleate showed significant iodination both during chromatography in the acidic solvent (63 per cent uptake) and during extraction from an acidified suspension (28 per cent uptake). The iodination of triolein resulting from butanol extraction in acid conditions is demonstrated in Fig. 2. During chromatography in butanol/formic acid, this compound took up 32 per cent of the radioiodine present.

It appears likely that artefacts could arise during the preparation and chromatography of tissue extracts containing inorganic radioiodide as a result of reactions similar to those described above. Lipoids may not be the only type of compound involved. Artefacts of this nature could probably be eliminated by avoiding extraction and chromatography in acid solution.

I wish to thank the Board of Governors of the United Sheffield Hospitals for financial assistance.

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May 12.

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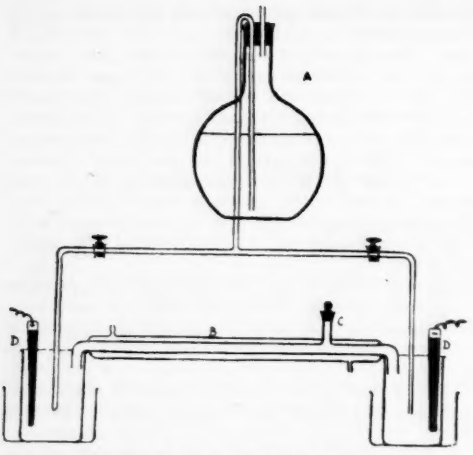
Ionophoretic Separation of Porphyrin Pigments

In the classical Tiselius procedure for electrophoresis of proteins, convection was prevented by the density gradient of the substances under investigation; but complete separation could not thereby be obtained, and the analysis was conducted by the observation of fronts. Later the medium was stabilized by silica or agar gel for the separation of amino-acids[1] and proteins[2]. Silica or agar gel will hold an excess of electrolyte and prevent convection currents; but it will allow substances to pass through independently and to separate into discrete bands. In addition, its use obviates contact of the moving substances with the electrodes.

Since porphyrin pigments are ampholytes, with differing numbers of carboxylic groups, it seemed likely that ionophoresis in a gel would provide a simple means of separation. Nicholas and Rimington[3] observed that the R_F values of porphyrins in paper partition chromatography were inversely proportional to the numbers of carboxylic groups in the molecule.

Agar gel was preferred to silica, since the former is easier to prepare, not so mechanically brittle, and gels in much higher dilution, thereby avoiding the introduction of large amounts of impurities. Nevertheless, stringent purification of the gel preparation was essential to avoid traces of metallic impurities, which would readily form complexes with porphyrins. Treatment with methanol[4] was found unsatisfactory as the product would not gel in the desired concentration. Satisfactory purification was achieved by washing powdered New Zealand agar (Davis) repeatedly with Sörensen *M*/15 phosphate



buffer *p*H 8·0 and then allowing it to stand over-night in the buffer. The volume was adjusted to give 0·5 or 1 per cent agar and the mixture warmed in the water-bath until solution was complete (half an hour), when it was transferred immediately to the bridge of the ionophoresis apparatus. The agar gelled on cooling, and the residual impurities were removed by ionophoresis for three hours. This treatment appears to replace calcium and magnesium ions of the gel by the innocuous sodium and potassium ions of the buffer[5].

In the subsequent analysis of porphyrin pigments, these were detected by their intense ultra-violet fluorescence. The apparatus could therefore be simplified (see diagram) as compared with that required for proteins.

The procedure was as follows. A small section of agar gel was removed from the bridge *B* via the side-arm *C*, using suction through a Pasteur pipette. The porphyrin solution in *M*/15 phosphate buffer *p*H 8·0 or in phosphate agar (0·5 ml.) was introduced through *C*, and a direct electric current then passed through the bridge, which was water-cooled as illustrated. With a bridge length of 50 cm., D.C. mains voltage of 200 V. across the carbon electrodes *D* (that is, 4 V./cm.), cooling was not obligatory, but voltages greater than 4 V./cm. caused the temperature to rise higher than 55°, with liquefaction of gel and losses of pigments. Adequate cooling was also advantageous in preserving a steady electric current through the gel. The buffer in the electrode compartments was replaced continuously from the reservoir *A* at the rate of one litre an hour.

After ionophoresis for a period dependent on the voltage applied, the agar was withdrawn by gentle suction into a long glass tube, and the fluorescent portions cut out using a glass microscope slide. Ether-soluble porphyrins were reclaimed by heating the gel with one volume of 20 per cent w/v acetic acid for 30 sec., cooling and extracting immediately into ether. Uroporphyrin was removed by similar hydrolysis of the gel with one volume 5 per cent w/v hydrochloric acid, with subsequent cooling and shaking with chloroform. Traces of unhydrolysed agar were thereby precipitated, and other interfering blue fluorescent material was extracted into chloroform, leaving the uroporphyrin in the aqueous phase.

Our findings were as follows: (1) The porphyrins in untreated urines of acute or congenital porphyria migrated as discrete bands, and the presence of individual pigments was readily apparent. (2) Protoporphyrin (2 COOH), coproporphyrin (4 COOH) and uroporphyrin (8 COOH) had mobilities which increased with higher number of carboxylic groups. (3) Coproporphyrin isomers I and III were not separable, even with a tube 80 cm. long and proportionally greater voltage. Similarly, uroporphyrin isomers could not be distinguished. (4) No separation was observed in a mixture of the dicarboxylic proto-, deutero- and meso-porphyrins. (5) Sensitivity and recoveries were good. 1 μgm. of each porphyrin could be measured, with yields of 60–80 per cent of that amount.

Ionophoresis of porphyrins in agar gel is thus a simple procedure for separation of porphyrin on the basis of constituent carboxylic groups[3]. The effect of other substituents on mobilities at *p*H 8·0 appeared to be minimal and isomers could not be separated, although separation of coproporphyrin methyl esters has recently been effected by paper partition chromatography[6].

We should like to thank Dr. J. F. Wilkinson, director of this Department, for his continued interest in this work.

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The Soret Effect

Although thermal diffusion in condensed systems has been used experimentally for bringing about difficult separations, for example, in the Clusius and Dickel apparatus, and although considerable advances have been made recently in the descriptive treatment of the effect by Prof. S. R. de Groot[1] at Utrecht and Prof. Prigogine[2] at Brussels, experimental data by which theories of the Soret effect may be checked are still meagre.

According to de Groot, the shape of the thermal separation versus time curve is determined by the value of the diffusion constant at the mean temperature. The extent of thermal separation is not predictable, but the theory may be checked by evaluating the diffusion constant from time curves and making comparison with values found by conventional means for known systems.

Some measurements have been made in an apparatus similar to that used by me during 1924–27[3] in which the solution is confined in a shallow layer between horizontal metal surfaces at T and $T + \Delta T$ and optically analysed, without disturbance, by measuring the deviation produced in a horizontal beam of monochromatic light by the changing gradient of the refractive index. The method permits a nearly complete optical traverse to be taken between the top and bottom layers of the cell.

In orthogonally planned experiments with potassium chloride and barium chloride solutions in cells 0·695, 0·975 and 1·396 cm. high, with $T = 25°$ C. and $T + \Delta T = 35°$ C., diffusion constants required to satisfy the de Groot equations were substantially independent of cell height and concentration of solution, and in agreement with literature values for solutions ranging in mole fraction from 0·074 to 0·018 for potassium chloride, and from 0·019 to 0·002 for barium chloride.

The Soret coefficients for the above solutions are small, about 0·1–0·2 per cent per degree, and the measurements provided a test of the sensitivity of the experimental method.

It is hoped to publish the work in detail and to extend it to other systems.

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Cellular Permeability of Yeast to Metallic Ions

The apparatus devised by Dr. G. Protti for the kinetic study of cellular metabolism with radioactive isotopes[1] lends itself to permeability studies of yeast. We are using it to study their permeability to different metals.

The metal content of yeast is assumed constant, and the whole of the radioactive isotope is introduced at the beginning of the experiment. Then the rate of disappearance of radioactive metal ions is described by the differential equation:

$$\frac{V}{L}\frac{dx}{dt} = -\,v\,\frac{x}{Lb/V}\,v\,\frac{(x_0 - x)\,V/L}{a},$$

where a is gm. metal per gm. yeast; Lb/V is gm. metal ion per ml. solution; L is gm. yeast; V is ml. solution; x and x_0 are gm. radioactive metal ion per ml. solution at end and beginning of experiment respectively; t is time in hours; v is permeability measured in $\frac{\text{gm. metal}}{\text{gm. yeast hr.}}$.

Integrating this equation gives:

$$\frac{x}{x_0} = \frac{a.\exp\left(-\,v\,\frac{a+b}{ab}t\right)}{a+b}\,.\,b\,;$$

and then:

$$v = -\,\frac{1}{t}\,\frac{a.b}{a+b}\,\ln\left[\frac{x}{x_0} - \frac{b}{a}\left(1 - \frac{x}{x_0}\right)\right].$$

The validity of this equation has been confirmed by experiments using *Saccharomyces cerevisiæ* and copper-64 obtained from the Atomic Energy Research Establishment, Harwell; in these experiments, $v = 7{\cdot}2 \times 10^{-6}$.

Experiments with other metals are still in progress.

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A Novel Synthesis for Aroylacrylic Acids

This preliminary investigation was undertaken in an effort to apply the Doebner condensation to the synthesis of aroylacrylic acids according to the following equation:

$$\text{ArCOCHO} + \text{CH}_2(\text{COOH})_2 \xrightarrow{\text{pyridine}} \text{ArCOCH=CH—COOH} + \text{CO}_2 + \text{H}_2\text{O}.$$

The compound chosen for study was 2-naphthylglyoxal, because the properties of the resulting *beta*-2-naphthoylacrylic acid would help clear up certain doubts about its structure at the time this work was begun (however, see ref. 1).

2-Naphthylglyoxal was obtained easily in 75 per cent yield by oxidation with selenium dioxide of methyl 2-naphthyl ketone[2,3]. 2-Naphthylglyoxal monohydrate (15 gm.), malonic acid (7·5 gm.) and pyridine (15 ml.) were stirred for 22 hr. at room temperature. Carbon dioxide was evolved and a solid mass remained. The material was taken up in 5 per cent sodium carbonate solution and acidified to give a gummy semi-solid which hardened on standing several hours. Several recrystallizations from dilute alcohol (decolorizing carbon) gave a 12 per cent yield of bright yellow crystals of *beta*-(2-naphthoyl)-acrylic acid, melting point 164–166° [1] (calc. for $C_{14}H_{10}O_3$: C, 74·32; H, 4·46; neut. equiv., 226·2; found: C, 74·42, H, 4·56; neut. equiv., 227·1). The compound gave a rapid Baeyer's test and positive tests with phenylhydrazine and 2,4-dinitrophenylhydrazine. Tollen's reagent and Schiff's reagents were negative. It was quantitatively hydrogenated at 3 atmospheres pressure over a palladium-on-carbon catalyst to the known *beta*-2-naphthoylpropionic acid, melting point 170–172°. The acid is probably *trans*, since refluxing it with a crystal of iodine in either benzene or chloroform effected no change in the melting point.

Work to be reported elsewhere will show that this novel condensation is adaptable to the synthesis of negatively substituted aroylacrylic acids, such as *beta*-(4-nitrobenzoyl)acrylic acid—which are not obtainable through the conventional Friedel and Crafts reaction—and with considerable increase in yield over that reported here.

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Action of Alkaline Hypochlorite on 3 : 5 : 6-Trimethyl-*d*-gluconamide

The action of alkaline hypochlorite upon fully methylated hexonic and pentonic acid amides, using the Weerman procedure[1], results in the formation of cyclic urethanes[2]. Haworth, Peat and Whetstone[3], using this reagent, claimed the direct conversion of 3 : 5 : 6-trimethyl-*d*-gluconamide (which possesses a free α-hydroxyl group) to a 2 : 4 : 5-trimethyl arab-

inose, isolated as a syrup, to which a straight-chain aldehydic structure was ascribed.

The problem has been re-examined in this laboratory. Purified 3 : 5 : 6-trimethyl-*d*-gluconamide (obtained *via* 1 : 2-mono-*iso*-propylidene-3 : 5 : 6-trimethyl glucofuranose) melted at 138·5° and had $[\alpha]_D^{17}$ + 38·65° (water). Treatment of this amide according to the Weerman procedure, followed by the method of purification outlined by Haworth *et al.*, gave a syrup with properties almost identical with those described by these workers. However, the application of paper partition chromatography, using as mobile phase one part petroleum ether (100°–120°) and nine parts butan-3-one saturated with water, revealed the presence of at least four components of carbohydrate nature. Methods involving partition chromatography on cellulose columns resulted in the separation of four fractions, three of which each contain a different methylated pentose derivative. The fourth fraction contains little pentose but large amounts of organically bound nitrogen; it has not been further investigated at present.

Fraction 1 was obtained as a mobile syrup having $[\alpha]_D^{20}$ − 4° (1 per cent in methanol), n_D^{20} 1·4702 and OMe 34·5 per cent (theoretical value for a dimethyl pentose 34·8 per cent; for a trimethyl pentose 48·0 per cent). An aqueous solution of the syrup strongly reduced Fehling's solution in the cold, decolorized permanganate solution and immediately restored the colour of Schiff's reagent. These properties suggest a straight-chain aldehydic methylated pentose, and we presume this material to be responsible for the similar properties exhibited by the final product of Haworth *et al.*, since no other fractions obtained in the present experiments were capable of producing similar aldehydic effects.

Fraction 2 was obtained in small yield as an immobile syrup having $[\alpha]_D^{20}$ − 23·7° (1 per cent in methanol) and n_D^{20} 1·4730. This fraction also apparently consisted mainly of a dimethyl pentose derivative, since its OMe content was 34·4 per cent; but it showed none of the aldehydic properties of fraction 1 and the two fractions behaved very differently when subjected to paper partition chromatography.

Fraction 3, the largest fraction, was an immobile syrup consisting mainly of a trimethyl pentose having $[\alpha]_D^{20}$ + 13·2° (1 per cent in methanol), n_D^{20} 1·4718, and OMe 47·9 per cent (theoretical value 48·0 per cent). An aqueous solution of the syrup did not restore the colour of Schiff's reagent immediately, nor did it reduce Fehling's solution in the cold. After treatment with methanolic hydrochloric acid in a sealed tube at 100°, the methoxyl content increased to 59·3 per cent (theoretical value for a pentose with four methoxyl groups, 60·1 per cent) and the optical rotation became lævo, $[\alpha]_D^{20}$ − 12·5° (1 per cent in methanol), while n_D^{20} fell to 1·4530. The increase in methoxyl content and the change in the direction of the optical rotation indicate the presence of a hydroxyl group at C 1, and hence some ring structure, most probably propylene-oxidic, for the molecule as a whole.

Progress in this investigation awaits the isolation of crystalline derivatives, since the absolute homogeneity of each fraction is not claimed; and indeed certain chromatographic evidence indicates that fraction 3 may contain more than one trimethyl pentose. It is obvious, however, that under the conditions normally employed in the Weerman degradation reaction, the changes which 3 : 5 : 6-trimethyl-*d*-gluconamide undergoes are considerable and complex and appear to involve loss of methoxyl.

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Vision with a Stabilized Retinal Image

The small movements of the eye which persist when a subject fixates (that is, tries to gaze steadily at a given target) have been studied by several workers[1]. We have endeavoured to deduce the movements of the image across the retina from a recent study of the rotations of the eyeball[2]. The movements of the retinal image have the effect of moving the boundary between two regions of differing brightness across the retinal pattern of receptors and may therefore play an important part in vision.

It should be possible, by the following method, to obtain an image which does not move across the retina. The subject wears a contact lens which is specially made to fit his eye tightly and on which a small optical flat has been worked. The flat is covered (by vacuum evaporation) with a highly reflecting opaque film of rhodium. An image *I* of the object *O* is focused on to the screen *S* by means of the optical system shown in Fig. 1. The mirror *M* is the flat on the lens which is attached to the subject's own eye. The observer views *I* by reflexion in M_1 and M_2. His visual axis is in the direction *V* (see Fig. 2). If the distances are suitably adjusted, a small rotation of the contact lens moves *I* in such a way that the image of *I* on the retina is stationary. With the simple optical system shown it is possible to obtain compensation for *either* horizontal *or* vertical movements. A more complicated system enables both movements to be compensated at the same time. The adjustment of the optical system may be checked if the eye is replaced by a telescope with a small plane mirror attached to its object glass. When the

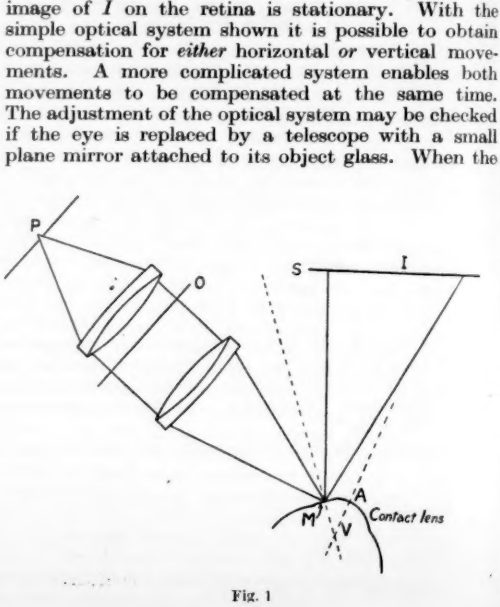

Fig. 1

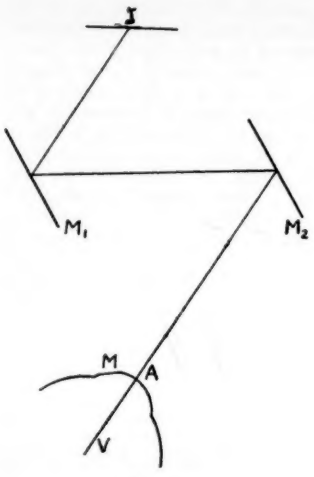

Fig. 2

adjustment is correct, the position of I with respect to the cross-wires is unaffected by a small rotation of the telescope.

Some preliminary experiments were made in 1945 by one of us (R. W. D.) in Dublin. It was found that the stabilized image disappeared at intervals. The results were not then published because they could not be repeated on every occasion, and because the necessary checks could not be made with the equipment then available. It was decided to use the contact lens method for studying the movements in detail before making another attempt to produce a stabilized image.

Recently, a fresh set of experiments has been carried out by the second author (B. L. G.). Only the horizontal components of the movements were stabilized. The object is shown in Fig. 3. The brightness of the right-hand area could be made 30, 40 or 60 per cent of that of the left-hand area. It was found that the line of demarcation disappeared and that A and B appeared to be of equal brightness for two or three seconds at intervals of about one minute. A second observer viewing I in the normal way did not observe any change. Similar effects were observed with other types of target. Although the effect is transitory, it is repeatable. The contrast threshold for the stabilized image is thus very much higher than the normal threshold for the same brightness. It seems that the eye recognizes that the situation is abnormal and makes some adjustment (possibly of accommodation) which temporarily defeats the stabilization causing the image to reappear.

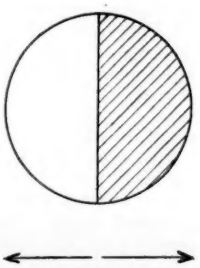

Fig. 3

The present experiments are regarded as showing, in a qualitative way, that the eye movements have a significant function. A further development of technique will be needed to obtain quantitative measurements.

One of us (B. L. G.) was in receipt of a maintenance grant from the Department of Scientific and Industrial Research during the period of this research.

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Some Speed, Error and Difficulty Relationships within a Problem-solving Situation

During the past three years, experiments have been conducted with subjects who have been given the task of solving mental-test items of a particular type[1] (Thurstone 'letter-series' items). Suppose P_C be the probability that a particular subject will continue to work at a particular problem for some time t before giving it up, and let P_E be the probability that if a solution is recorded within this time it will be the correct one. If the universe of discourse is now restricted to correctly solved items, the probability (P_S) that a particular correct solution will be returned within a period of t sec. after the moment the problem is presented will be a function both of the dynamics of the problem-solving process as such and also of P_C, for if $P_C \neq 1$ at time t then P_S must be modified, and if $P_C = 0$, P_S must be zero also. Let P_S be defined as the probability which would obtain if $P_C = 1$ for $t = \infty$. No comprehensive statement can be made about a person's ability to solve a problem which does not involve at least these three probabilities, that is, any attempt to measure 'intelligence' by mental-test methods should involve assessments of P_C, P_E and P_S.

No valid analysis of the experimental data can be made outside the range of difficulties defined by $D = 85$ and $D = 10$ (where D is as defined below) for reasons which will be discussed elsewhere. Within these limits, they strongly support the hypothesis that :

$$P_S = \int_0^t \frac{1}{\sigma_S\sqrt{2\pi}} \exp - (\log t - mD + S)^2/2\sigma_S^2 \mathrm{d}t \quad (1)$$

$$P_C = 1 - \int_0^t \frac{1}{\sigma_C\sqrt{2\pi}} \exp (\log t - C)^2/2\sigma_C^2 \mathrm{d}t \quad (2)$$

$$P_E = 1 - \int_0^D \frac{1}{\sigma_E\sqrt{2\pi}} \exp (D - E)^2/2\sigma_E^2 \mathrm{d}D, \quad (3)$$

where σ_S, σ_C, σ_E all have the usual connotations for a normal distribution, D is the difficulty of the problem being considered, defined in the conventional but arbitrary fashion $D = [100 - R]$, and R is the percentage of an adult British population (unselected) who achieve success with the item ; m is the slope

$d(\log t)/dD$, in the usual way. S, C and E are constants which define the subject's speed, continuance (a function of persistence) and solution–recognition–efficiency (see definition of P_E) within the test situation being studied.

If a problem is incorrectly solved, and if t_w is the time elapsing between the presentation of the problem and the recording of an incorrect solution, then :

$$P_w \text{ does not have the same form as } P_S, \quad (4)$$

where P_w is the probability that the incorrect solution will be returned within a period t_w.

Equation (3) is of the same form as expressions suggested by Thorndike and Thurstone. So far as I know, (1) and (2) have not previously been advanced. The main interest of these results centres about (1), for there is very strong evidence that m and σ_S are identical for all the subjects who have so far been examined, not only within a particular test situation, but also between situations involving different degrees of motivation. $m = 0{\cdot}013$ ($S.E._{est.} = 0{\cdot}0005$) and $\sigma_S = 0{\cdot}12$ ($S.E._{est.} = 0{\cdot}005$), all values being in log-sec. units. The range of values of S encountered experimentally is such that as $D \to 0$ both m and σ_S must depart from these values. Such evidence as is available suggests that both parameters retain their values in the region $D > 85$. It seems probable that these two parameters can join Philpott's[2] fluctuation constants, p and T_0, bringing the number of true psychological constants up to four. There is presumptive, but not as yet conclusive, evidence that σ_C (1) is also a true constant.

It follows immediately from equations (1)–(4) that, when attempting to measure S, all the test items used should be easy and of identical difficulty, and that only items correctly solved can be used in calculating the score obtained. Existing methods of measuring mental speed ignore these requirements so completely that it seems justifiable to make this point even in a preliminary communication of this nature. Adherence to these principles has made possible the design of a speed-test which requires only some 15 min. to administer, and in connexion with which the concept of (statistical) 'reliability' can legitimately be used ($r_{1I} \simeq 0{\cdot}9$). Equation (2) leads directly to a method of designing 'cognitive' tests in such a fashion that they can be scored for persistence as well as for the ability ostensibly under examination.

It is possible that σ_S results from the functioning of some kind of cerebral 'search' mechanism. For example, if the successful solution of a problem of difficulty D_b were to involve the bringing into relationship of b neural elements which had to be correctly selected in the right order from a pool of n elements, then we can postulate that for some time t_1 the search mechanism examines relationships involving less than b elements, so that no solution to a problem of difficulty D_b can ever occur during this time. At time $t_1 + \delta$ the first relationship involving b elements occurs, and relationships of this complexity continue to occur until all have been examined after time t_2. The suggestion is that σ_S is a function of the interval $(t_2 - t_1)$ and of the frequency with which correct solutions arise at different values of t within these limits, rather than of the error of determination of some value t_b which is the 'true' time for solution for all problems of difficulty D_b. The characteristics of a number of possible search mechanisms are now being examined in detail in the hope that the time-difficulty relationships of one of them will satisfy the requirements of equation (1), while at the same time being physiologically plausible. It is interesting to note that if the problem-solving process in any way resembles that suggested above, then item difficulty is a discontinuous variable, no values of D being possible between D_b and D_{b+1}.

This work has been carried out in the course of an investigation of methods of selecting students for universities which is sponsored by the Nuffield Foundation. Short papers presenting successive stages of the analysis were read before the Twelfth International Congress of Psychology[3] (Edinburgh 1948) and the British Psychological Society[4] (London 1950). A full report is being prepared for publication.

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Male Sterile Plants by Chemical Treatment

It is well known that treatment with 'growth hormones' reduces the fertility of plants. Not only do the 'auxins' seem to be antagonistic to the initiation of flowering, but also they reduce the number of seeds that develop from treated flowers, or they may cause total sterility. This effect is used in blossom-thinning sprays and in the production of parthenocarpic fruits.

The reasons for the sterility induced by chemical treatment have not yet been thoroughly investigated. Recently, Moore[1] and Naylor[2] reported that maleic hydrazide, a plant-growth inhibitor, produces only male sterility in maize, whereas the female flowers remain fertile and set seed after pollination with pollen from untreated plants. A method of inducing male sterility leaving the female organs fertile by a simple chemical treatment would be of great importance for the production of hybrid seed not only with maize but even more so with many other cultivated plants, where emasculation and pollination by hand are prohibitive to the production of hybrid seed on a large commercial scale, or where this method is impossible for technical reasons such as smallness of reproductive organs. Also with many breeding problems, for example, with beet, carrots, rye, such a method could be very helpful.

Plants of Hawksbury and Cape Mountain Sweet water-melons were treated with various concentrations of 2,4-dichlorophenoxyacetic acid, tri-iodobenzoic acid and maleic hydrazide. The chemicals were applied, about a week before the first flowers opened, to all parts of the plants in a hill as a spray in aqueous solution with a wetting agent. Degree and duration of male sterility were checked by pollinating protected female flowers from untreated plants with pollen from the treated plant. The female flowers of the treated plants were left open for pollination by insects.

The checking for male sterility was started one to three weeks after treatment. Full male sterility for

more than one week was found with the following treatments: 10 p.p.m. tri-iodobenzoic acid, applied every week; 50 p.p.m. tri-iodobenzoic acid, application repeated once after four weeks; 250 p.p.m. tri-iodobenzoic acid, applied once; 5 p.p.m. 2,4-dichlorophenoxyacetic acid, applied every week. The pollen of the male sterile plants showed various abnormalities: grains with more or less vacuolated plasma, small, shrivelled, empty grains, and in the variety Cape Mountain Sweet, often a high percentage of giant, unreduced grains. In sterile pollen these visible abnormalities amounted always to 20 or more per cent.

The female flowers which opened in all these treatments during the period of male sterility were at least partly fertile. As with untreated plants, not all the female flowers set fruit, and some fruits grew only to a quarter or a half the size of normal fruits, but with fully developed seeds. The best fruit set was found with the plants treated with 250 p.p.m. tri-iodobenzoic acid, a very poor set with the plants treated weekly with 5 p.p.m. 2,4-dichlorophenoxyacetic acid, but this treatment had generally also a very detrimental effect on the growth of the plant.

Lower concentration of 2,4-dichlorophenoxyacetic acid and tri-iodobenzoic acid did not produce full male sterility. Maleic hydrazide was used only in the concentrations 250 and 500 p.p.m. These concentrations caused only a short inhibition of the vegetative growth, after which the plants were found fully fertile.

Laibach and Kribben[3] succeeded in increasing the proportion of female flowers in cucumbers by treatment with α-naphthalene acetic acid and β-indolyl acetic acid. The suppression of all male flowers would be another way of producing purely female plants. If applied to young water-melon plants, tri-iodobenzoic acid produces a higher proportion of female flowers (in two cases the first flowers which opened on a plant were female, whereas on untreated plants only male flowers open for some days before the first female flower appears), but never suppressed the formation of male flowers entirely. More successful was the treatment of a wild *Citrullus vulgaris* plant in full bloom which had only male and hermaphroditic flowers. Before treatment, this plant had a proportion of 10·1 male to 1 hermaphroditic flower. From the thirteenth to the twenty-second day after treatment with 50 p.p.m. tri-iodobenzoic acid, this changed to 0·8 male to 1 hermaphroditic, and for two days only hermaphroditic flowers opened. (During this period the bisexual flowers were self-sterile, the open-pollinated flowers set fruit.) A similar behaviour was shown by a cucumber plant in the greenhouse (variety Early Fortune), which after treatment with 25 p.p.m. tri-iodobenzoic acid produced five male and seven female flowers over a period of five days, and during two days only female flowers. (The male flowers were sterile; one of the female flowers developed seed after pollination with pollen from an untreated plant.)

As most of the work on parthenocarpy by chemical treatment has been done with tomatoes, some additional experiments were made with this plant. The plants were grown in pots in the greenhouse and treated about a week before the first flowers opened. Sterility for about eight weeks was obtained with 25, 50 and 100 p.p.m. tri-iodobenzoic acid and 10, 25 and 50 p.p.m. 2,4-dichlorophenoxyacetic acid, whereas 50 p.p.m. naphthalene acetic acid and 500 p.p.m. maleic hydrazide induced sterility for only 10–14 days. Crosses with pollen from untreated plants showed that the ovules of plants treated with 25 and 50 p.p.m. tri-iodobenzoic acid are able to produce seed during the period of sterility. 2,4-Dichlorophenoxyacetic acid in the concentrations used inhibits growth and flower formation for several weeks and seems to impair also the fertility of the female organs; no definite conclusions on the female fertility of the tomato plants treated with this substance can be made at this stage. The microscopic examination of the sterile tomato pollen showed visible abnormalities of the grains, various degrees of vacuolization, or coagulation of the plasma, or a certain percentage of small, empty grains.

It has been shown that treatment with certain growth-regulating substances produces male sterility in cucurbitaceous plants and in tomatoes for periods of one to several weeks.

These investigations are being continued. A full report will be published elsewhere.

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Detoxication of Hormone Herbicides by Soil Bacteria

The selective herbicides 2,4-dichlorophenoxyacetic acid (DCPA) and 2-methyl-4-chlorophenoxyacetic acid (MCPA) are known to undergo a gradual detoxication in soil due to biological agencies, and Audus[1,2] has recently reported the isolation of a bacterium capable of decomposing the former, which is apparently utilized as a source of carbon. In the course of work on herbicide detoxication in soil, we have succeeded in isolating two types of bacteria with similar properties from soil repeatedly treated with 2,4-dichlorophenoxyacetic acid. Pure cultures were readily obtained by plating from soil on an agar medium containing 0·10 per cent sodium salt of the acid as the sole source of carbon. The first organism (No. 1) grew abundantly in ordinary bacteriological media and was identified as *Flavobacterium aquatile* (Bergey[3]). The second (No. 2) bore some morphological resemblance to the organism studied by Audus—small, irregular, non-spore-forming, non-motile rods of a *Corynebacterium*-like appearance, but Gram-negative, sometimes with Gram-positive granules. It grew very feebly in ordinary media and showed no conspicuous biochemical activities; but on ammonium phosphate agar with 0·1–0·2 per cent sodium salt of 2,4-dichlorophenoxyacetic acid or 2-methyl-4-chlorophenoxyacetic acid it produced a slow but eventually quite vigorous, whitish and slimy growth. A mere trace of growth occurred on the basal medium without added organic matter. Glucose and glycerol were utilized very poorly; phenol, sodium benzoate and sodium salicylate not at all.

Measurements of the evolution of carbon dioxide from garden soil plus 0·01 per cent sodium salt of either acid, inoculated with cell suspensions of the two bacteria, showed that 50–100 per cent of the carbon added in the herbicides was liberated as carbon dioxide after two to three weeks at 25° C. After

the experiment, tests with barley seedlings (percentage germination, and weight of sprouts) showed that the toxic effect of 2,4-dichlorophenoxyacetic acid had been completely abolished by both bacteria, and that of 2-methyl-4-chlorophenoxyacetic acid also by Bacterium No. 2. Cultures of both bacteria, when freshly isolated, also detoxified the former in solid (2 per cent) agar medium with ammonium phosphate as a source of nitrogen (see Table 1).

Table 1. Incubation 28 Days at 25° C.

Medium	Percentage germination of barley	Fresh weight per 100 sprouts of barley (gm.)
Agar + 0·005 *M* DCPA, sterile	9	0·22
„ inoculated with *F. aquatile*	98	6·28
„ inoculated with Bacterium No. 2	98	5·03
Sterile agar without DCPA.	99	6·63

Unlike Audus[1,2], we observed no significant detoxication by either organism in semi-solid (0·2 per cent) agar medium, or in soil extract.

After several transfers, *F. aquatile* grew very feebly on 2,4-dichlorophenoxyacetic acid but was still able to decompose this substance in sterile soil, like Bacterium No. 2, which also decomposed 2-methyl-4-chlorophenoxyacetic acid.

Table 2. Garden Soil Sterilized by Autoclaving and Incubated at 25° C. for Fifteen Days (with 2,4-Dichlorophenoxyacetic Acid) or for Fourteen Days (with 2-Methyl-4-chlorophenoxyacetic Acid)

Treatment	Percentage germination of barley	Fresh weight per 100 sprouts of barley (gm.)
Soil without addition, sterile	96	4·30
Soil + 0·01 per cent DCPA (sodium salt), sterile	47	0·79
„ inoculated with *F. aquatile*	98	4·31
„ inoculated with Bacterium No. 2	95	4·49
Soil without addition, sterile	96	4·86
Soil + 0·01 per cent MCPA, sterile	43	0·95
„ inoculated with Bacterium No. 2	95	4·64

In other experiments we obtained complete detoxication of 0·01 per cent 2,4-dichlorophenoxyacetic acid by *F. aquatile* in five days, but this organism was not active towards 2-methyl-4-chlorophenoxyacetic acid.

Two entirely different species of bacteria, one of which may be related to Audus's organism, are thus able to detoxify 2,4-dichlorophenoxyacetic acid, and one of them also 2-methyl-4-γ-chlorophenoxyacetic acid. The very feeble growth of the latter organism in all media except those containing the two herbicides suggests that it may be an induced mutant of some other soil bacterium which has become specialized in the utilization of a few cyclic compounds.

The results of our experiments will be published in detail elsewhere.

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Root Parasites in Loranthaceæ

The plant family Loranthaceæ (mistletoes, etc.) contains several hundred species, almost all partial parasitic shrubs growing on the branches of trees. The following species are terrestrial shrubs or trees: *Nuytsia floribunda* R.Br., of Western Australia, several South American species of *Gaiadendron* G. Don, and *Atkinsonia ligustrina* (A. Cunn. ex F. Muell.) F. Muell., which is known only from the Blue Mountains of New South Wales, where it occurs sporadically on dry rocky ridges. This small group of terrestrial species is stated by various authors (for example, Macgregor Skene[1]; Moore and Betche[2]) to be non-parasitic; but Herbert[3] has shown that *Nuytsia floribunda* is a root parasite, as was indeed conjectured by Harvey[4] in 1854. It attacks a wide range of hosts, including both native and introduced species. *Atkinsonia ligustrina* has now been investigated at Woodford, N.S.W., and shown to form haustoria attached to the roots of several host species, including *Acacia intertexta* Sieb., *Platysace linearifolia* (Cav.) Norman (syn. *Trachymene linearis* Spreng.) and the narrow-leaved form of *Leptospermum attenuatum* Sm. Thus, of the terrestrial Loranthaceæ, only the species of *Gaiadendron* (with which *Atkinsonia ligustrina* was associated systematically by Bentham and Hooker[5] and by Engler[6]) are not known to be parasitic. It would not be surprising if they too should prove to be root parasites.

It is hoped to publish elsewhere some details of the relations between *Atkinsonia* and its host plants.

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Observation of Egg-laying under Water of the Aerial Insect *Hydropsyche angustipennis* (Curtis) (Trichoptera)

Doubt has existed about the mode of egg-laying in certain caddis flies, especially those the eggs of which are found under water in flat sheets cemented to the lower surface of stones. Accounts for most of these species are based on indirect evidence and incomplete observation. Consequently the following direct observation on the entry of *Hydropsyche angustipennis* into a watery medium may be of interest.

Unlike many Trichoptera, this caddis fly is not crepuscular, and on a sunny June afternoon an imago was observed alighting on a stone projecting above the water surface in an upland stream at Craigton, near Glasgow. She remained there for some moments with her antennæ bending over so that the tips were in the water, then suddenly flew up two or three feet, zig-zagged rapidly over the stream for a few yards and dived vertically down into the water. Air carried down on the hairy, folded

wings gave her a silvery appearance as she swam rapidly straight to the lower surface of an inclined submerged stone. The stream here was about 9 cm. deep and the current velocity less than 15 cm. per second. These observations tend to confirm Wilson's remarks on *Stenopsyche* as recorded by McLachlan[1]. When, after a few seconds, the stone referred to above was raised and the female captured *in situ*, it was found that she had already deposited some eggs in a flat sheet with transparent, colourless cement between them. The captured female was kept in captivity, surviving for two days during which she again entered the water and laid some 460 eggs while continuously submerged for 37 min. Details of these observations will be given in a later paper.

The method of respiration enabling this aerial insect to remain under water for so long while performing strenuous activities requires further investigation. Possibly air carried down on the hairy body surface functions as a physical gill. It is doubtful whether a plastron is formed in caddis flies; it has only been demonstrated in certain aquatic beetles and in the bug *Aphelocheirus*[2].

In *H. angustipennis* there are no striking morphological adaptations for swimming such as have been described by McLachlan as indicative of possible swimming powers in *Amphipsyche*[3]. The female imago of *H. angustipennis* is bigger than the male; but relative to body-size there is little difference in the limbs of the two sexes. A fringe of hairs found only on the mesothoracic tarsi of the female might possibly aid in swimming.

The observations noted above may be significant in considering the ecological distribution and population density of this species; for example, the speed of the current may affect the ability of the female to reach suitable sites for oviposition and become a limiting factor in determining distribution.

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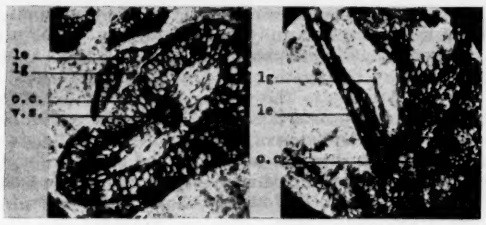
A Ligulate Pteridophyte from the Lower Coal Measures of Bacup, Lancashire

THE specimen to be described is a coal-ball petrifaction from the Old Meadows Pit, Bacup, Lancashire, and consists of a main axis, which followed a very sinuous course in the coal-ball. Of this axis the tissues of the outer cortex and the stelar xylem only are preserved, there being a wide space between the outer cortex and the central stele.

Interest in the specimen was stimulated by the observation that curious appendages were borne on the main axis, these appendages being very similar to Stigmarian rootlets but bearing ligulate leaves.

The vascular cylinder of the main axis, like the whole axis, followed a sinuous course in the coal-ball and only xylem tissue is preserved. The xylem consists of a solid core of primary xylem and some secondary xylem. The primary xylem is of scalariform tracheids only, with no recognizable protoxylem, although the central elements are smaller than the peripheral ones. In transverse section the secondary xylem appears as wedges of regularly arranged elements separated by wide primary medullary rays, the tissues of which are not preserved, but in each ray a xylem trace passes out from the primary xylem. These rays and xylem traces are clearly seen in longitudinal sections, and in longitudinal tangential sections the secondary xylem presents the appearance of an anastomosing network of elements with a xylem trace in the centre of each mesh. The secondary xylem elements are tracheidal in nature, show scalariform thickening, but are narrower and very much shorter than the primary xylem elements. Where preservation is sufficiently good, both primary and secondary xylem elements show the fine threads of thickening extending in a vertical direction between the transverse bars of thickening, a feature characteristic of the xylem of Lepidodendroid plants. The stelar xylem as a whole measures 2·5–3·0 mm. in diameter and the primary xylem 1·25–1·5 mm. in diameter.



(*A*) (*B*)

A, Transverse section leafy appendage; *B*, longitudinal section outer tissues of leafy appendage (× 25). *le.*, leaf; *lig.*, ligule; *o.c.*, outer cortex; *v.s.*, vascular strand

The preserved remains of the cortex of the main axis, which is outer cortex, may be divided into two zones. The outer zone is part of the original outer cortex, while the inner zone, consisting of regular thin-walled cells, is phelloderm developed centripetally from a phellogen situated just inside the outer zone. No evidence can be found of leaves being borne on the main axis; but embedded in its outer cortex are the bases of the curious leafy appendages, which thus appear to arise endogenously.

The leafy appendages are bud-like structures, 1·5 mm. average diameter, with monarch xylem of rarely more than six tracheids. The tissue immediately outside the xylem is badly preserved and its nature is indeterminate (Fig. *A*). Between the monarch vascular strand and the outer cortex in the better preserved examples are strands of cells forming trabeculæ. Borne on these appendages are leaves, 3·3 mm. long, 0·6 mm. wide and 0·15 mm. thick at the base. These leaves possess neither vascular tissue nor stomata, and they are definitely ligulate (Figs. *A* and *B*). The ligule is 0·33 mm. long, four or five cells wide at the base and two cells thick, except at the tip.

Transverse and longitudinal sections of the cortex of the main axis show these appendage origins as cylindrical masses of parenchymatous tissue, in the centre of each of which is a very small vascular strand. Passing outwards through the cortex the vascular strand becomes better developed, but the parenchymatous cells around it become disorganized except for the trabeculæ. After careful searching it has been found impossible to show any connexion between the xylem of these appendages and the xylem of the traces which depart from the periphery of the primary xylem of the main axis.

The leafy appendages raise very interesting points. They may represent fully developed adult structure or they may be young stages of an arborescent type, or they may be organs of vegetative propagation.

In some respects the specimen is reminiscent of *Stigmaria bacupensis* Scott et Lang[1]; for example, in size. The diameter of the main axis, of the stele and of the appendages are all of the same order as in *S. bacupensis*; but this new specimen differs from *S. bacupensis* in the following features: (1) the protostele has no recognizable protoxylem; (2) the cortex of the main axis has quite a different structure; (3) the outer cortex of the appendages differs from the outer cortex structure of the rootlets of *S. bacupensis*; (4) the appendages bear leaves.

The structural features of this new specimen suggest a Stigmarian axis bearing appendages rather similar to Stigmarian rootlets; but the appendages of this new plant bear leaves and the leaves bear ligules. It may be that this new specimen indicates that the so-called rootlets of *Stigmaria* are really of stem nature. In this connexion it is interesting to note that in the same coal-ball and in close proximity to the specimen just described are remains of outer cortical tissues which are identical in structure with those of the new specimen, but this cortex bears ordinary Stigmarian rootlets and not leafy appendages.

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Supra-vital Staining of Striated Muscle with Tetrazolium Compounds

The fact that a nearly colourless solution of 2 : 3 : 5 triphenyl tetrazolium chloride (tetrazolium salt) is reduced to a red formazan in contact with living tissue has been recognized for some time. This has been used in testing for viability and also for staining tissues; but detailed descriptions of the colour distribution within tissues are lacking. Since the red colour is due to reduction of the agent, the colour distribution should offer some evidence as to the intracellular distribution of reducing groups.

In the present work, small strips of striated muscle from freshly killed mice have been teased out in a 0·1 per cent solution of tetrazolium in normal saline or Ringer–Locke solution. The preparations were mounted under cover slips, ringed with a 'Vaseline'-wax mixture and examined immediately. The red colour appears within 3½ min. and continues to intensify until all the muscle fibres are deeply stained. Under the high-power microscope, the colour is seen to be concentrated in transverse bands in the muscle, while the intervening bands are but faintly stained; a narrow band of intermediate staining intensity traverses the centre of the faint band. This is illustrated in Fig. 1. Apart from the coloration, the appearance is very similar to that seen in a phase-contrast picture (cf. Fig. 2).

Experiments with the related compounds 2,2′-(*p*-diphenylene)-*bis*(3,5 diphenyl tetrazolium chloride) (neotetrazolium) and 2-(*p*-iodophenyl)-3-(*p*-nitrophenyl)-5-phenyl tetrazolium chloride (iodotetrazolium) have given similar results. In the case of neotetrazolium, the reduction colour is a deep purple-black, and in some preparations the longitudinal striæ of the muscle fibres have also appeared. The distinctive distribution of the colour is strongly suggestive of a similar distribution of reducing groups within the muscle fibre. Since the overall picture remains the same despite intensification of the colour, it appears unlikely that the result achieved is dependent upon differential rates of infiltration of the agent into the various portions of the muscle fibre.

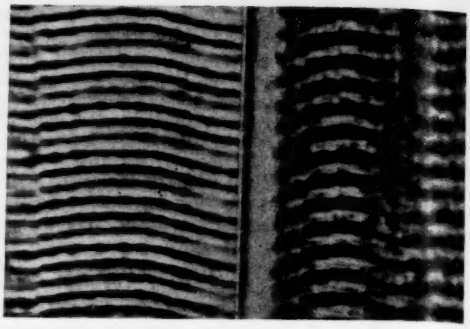

Fig. 1. Striated muscle stained with tetrazolium. (× 1,500)

Fig. 2. Striated muscle, unstained (phase contrast. × 1,500)

It appears, then, that these salts not only provide a useful tool for histological demonstration, but may also offer evidence as to the distribution of cellular components.

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Noradrenaline and Accessory Chromaffin Tissue

Fulk and Macleod[1] showed that the retro-peritoneal tissue of many mammals contains a material which, like extracts of the suprarenal glands, produces inhibition of the isolated rabbit intestine and excitation of the isolated rabbit uterus. Using histological methods, Wislocki[2] confirmed that there is abdominal chromaffin tissue in these animals. Whereas Mulon[3] showed that the chromaffin tissue in the carotid bodies of horses contains a pressor substance, Fulk and Macleod[1] failed to obtain any sympathomimetic substance in extracts of the thoracic aorta (containing the chromaffin tissue of the cardioaortic bodies). Recently, West, Shepherd and Hunter[4] reported that the collection of chromaffin tissue known in babies as the organs of Zuckerkandl contains large amounts of noradrenaline. The paraganglia are situated along the aorta near the origin of the inferior mesenteric artery. We have therefore attempted (*a*) to confirm that a sympathomimetic substance is present in accessory chromaffin tissue of animals, and (*b*) to identify such a substance by biological and chromatographic methods[4].

The results shown in the accompanying table indicate that large amounts of noradrenaline may be found in the retro-peritoneal tissue of young dogs, rabbits, guinea pigs and cats, and in certain cases

ABSOLUTE AMOUNTS (μGM.) OF ADRENALINE AND NORADRENALINE IN ANIMAL TISSUES

Species	Age	No. of expts.	Suprarenals		Retro-peritoneal tissue	
			Adrenaline	Noradrenaline	Adrenaline	Noradrenaline
Rabbit	*In utero*	6	0	4	0	4
	1 hr.	8	4	5	0	12
	1 day	4	0	7	0	5
	2 days	10	5	5	0	5
	4 days	6	10	2	0	2
	Adult	8	92	0	0	0
Dog	1 day	1	10	10	0	15
	6 days	1	45	20	0	12
	9 days	1	50	25	0	10
	Adult	1	560	260	0	0
Cat	*In utero*	4	3	10	0	3
	12 hr.	4	16	70	0	25
	1 day	2	20	70	0	10
	3 days	2	40	60	0	5
	Adult	10	120	80	0	0
Guinea pig	*In utero*	2	0	5	0	10
	1 hr.	2	5	5	0	10
	2 days	4	20	5	0	3
	Adult	8	71	0	0	0

this amount exceeds that found in the suprarenal glands. These additional chromaffin structures must therefore perform some autonomic function early in life—perhaps the maintenance of blood pressure. As the animal grows older and the suprarenal medulla matures, so the amine content of this accessory tissue declines. On the other hand, extracts of the carotid bodies and of the aortic bodies of rabbits, cats and guinea pigs did not yield any sympathomimetic material. This may not be so surprising, since chromaffin tissue is not necessary for the production of adrenaline and noradrenaline. Precursors of noradrenaline, such as hydroxytyramine and dihydroxyphenylalanine, were not detected in any of the above extracts.

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Effect of Cortisone on the Blood Pressure of Normal Rats

THE importance of the adrenal cortex in the regulation of the blood pressure has recently been emphasized by several authors. The effect of prolonged treatment with high doses of cortisone on the rat's blood pressure was therefore investigated.

Seventy-two male white rats weighing 144 ± 3 gm. were fed on a synthetic diet containing 30 per cent proteins, 56 per cent carbohydrates, 10 per cent lipids, 4 per cent McCollum salt mixture and supplements of vitamins and lipotropic factors; water was allowed *ad libitum*. Forty-six rats were injected subcutaneously with 5 mgm. of cortisone acetate ('Cortone', Merck) daily for twelve days; 26 controls received injections of 0·9 per cent sodium chloride solution. The blood pressure was measured by the method of Friedman and Freed[1]; in ten experimental animals and in ten controls the electroencephalogram was taken (lead 2) and their plasma and blood volumes were determined after a fast of 12 hr., using Evans blue according to the method of Wang and Hegsted[2].

The mean blood pressure of the controls was 119 ± 3·5 mm. mercury at the beginning of the experiment; after twelve days the value was practically unchanged (121 ± 4 mm. mercury). In the cortisone-treated rats the blood pressure increased from the initial value of 115 ± 3 mm. mercury to 140 ± 5 mm. after twelve days of treatment. The difference is statistically significant ($P < 0.01$). No definite modification of the electroencephalogram was found, except a significant increase of the heart-rate in the cortisone group (440 ± 15 beats per min. against 340 ± 11 in the controls).

At the end of the experiment, plasma and blood volumes were respectively 3·6 ± 0·2 c.c. and 6·8 ± 0·3 c.c. in the controls and 3·5 ± 0·4 c.c. and 6·6 ± 0·8 c.c. in the cortisone-treated animals (values referred to 100 gm. final weight). The weight of the heart and of the kidney was increased in the cortisone group, when referred to 100 gm. final body-weight, but remained unchanged when referred to 100 gm. initial body-weight. Histological examinations failed to show arterial lesions in the kidneys and the heart in either of the two groups.

Our observations suggest that large doses of cortisone given to normal rats fed on a balanced diet and with a normal intake of sodium chloride have a hypertensive effect, which seems to be accompanied by an increase of the heart-rate. It is not associated with changes of the blood volumes or with vascular lesions in the kidney.

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A Unit of Wave-number

A YEAR ago[1], names suggested for the unit 'cm.$^{-1}$' were permicron, Rydberg and Balmer. In a recent review[2] of "Modern Interferometers", Prof. W. F. Meggers advocates 'Kayser'. Where early workers used the reciprocal of the wave-length in air, H. Kayser recognized that in complex spectra the wave-length in vacuum is essential, and so gave to 'cm.$^{-1}$' its proper definition. Moreover, he compiled the tables still used in the conversion. These arguments are convincing; the more so as Rydberg is commemorated by a constant and Balmer by a series, while K is here a more convenient symbol than R.

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University, Bristol 8.
April 3.

[1] Bayliss, N. S., *Nature*, **167**, 387 (1951). Candler, C., *Nature*, **167**, 649 (1951). Bladergroen, W., *Nature*, **167**, 1075 (1951).
[2] Meggers, W. F., *J. Opt. Soc. Amer.*, **41**, 106 (1951).

FORTHCOMING EVENTS

(Meeting marked with an asterisk • is open to the public)

Monday, July 7

ROYAL SOCIETY OF EDINBURGH (at 24 George Street, Edinburgh), at 4.30 p.m.—Prof. James Kendall, F.R.S.: "The First Chemical Society, the First Chemical Journal and the Chemical Revolution".

Monday, July 7—Saturday, July 12

INTERNATIONAL DIABETES FEDERATION (at Leyden, the Netherlands).—First International Congress.

MINISTRY OF FUEL AND POWER (at the Safety in Mines Research Establishment, Buxton).—Seventh International Conference of Directors of Safety in Mines Research.

Thursday, July 10—Friday, July 11

PHYSICAL SOCIETY (at Glasgow).—Summer Meeting.

Friday, July 11

UNIVERSITY OF LONDON (in the Clinical Theatre, Middlesex Hospital, Mortimer Street, London, W.1), at 5.30 p.m.—Prof. L. T. Samuels (Utah): "Enzymes Involved in the Synthesis of the Steroid Hormone".•

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN THE DEPARTMENT OF PHARMACEUTICS—The Clerk to the Council, School of Pharmacy, 17 Bloomsbury Square, London, W.C.1 (July 10).

BERRIDGE STUDENTSHIP IN PHYSIOLOGY as applied to public health—The Registrar, King's College, Strand, London, W.C.2 (July 11).

ASSISTANT (Grade B) to teach PURE MATHEMATICS to Intermediate Degree and PRACTICAL MATHEMATICS to A1 level, at the Rutherford College of Technology—The Director of Education, City Education Office, Northumberland Road, Newcastle-upon-Tyne 1 (July 12).

ASSISTANT LECTURER (temporary) IN BIOCHEMISTRY—The Registrar, The University, Sheffield (July 12).

PHYSICIST (with an honours degree in physics) to the Radiotherapeutic Department—The Group Secretary Ipswich Group Hospital Management Committee, Anglesea Road, Ipswich (July 12).

SCIENTIFIC OFFICER (with a first-class or a good second-class honours degree in either physics or mechanical sciences) at the Agricultural Research Council's Unit of Soil Physics at Cambridge—The Secretary, Agricultural Research Council, 15 Regent Street, London, S.W.1 (July 12).

LECTURER IN CIVIL ENGINEERING at University College, Dundee—The Secretary, The University, St. Andrews (July 15).

GRADUATE ASSISTANT IN STATISTICS, for teaching, consultation and research in statistical science and biometry—The Lecturer in the Design and Analysis of Scientific Experiment, 6 Keble Road, Oxford (July 18).

READER IN EXPERIMENTAL FLUID MOTION AND DIRECTOR OF THE LABORATORY—The Registrar, The University, Manchester 13 (July 21).

CHAIR OF BACTERIOLOGY in the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (July 26).

DEMONSTRATORS (2, with qualifications in microbiology, biochemistry, or related subjects) IN THE DEPARTMENT OF MICROBIOLOGY—The Professor of Microbiology, The University, Reading (July 26).

HEAD OF THE CHEMISTRY LABORATORIES at the Central Research Establishment, Stoke Orchard, Cheltenham—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/490 (July 26).

LECTURER IN ELECTRICAL ENGINEERING (with special reference to electrical machines and heavy current engineering)—The Secretary, University College, Gower Street, London, W.C.1 (July 28).

LECTURER IN MECHANICAL ENGINEERING at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

PROFESSOR OF APPLIED MATHEMATICS in the University of the Witwatersrand, Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

VENTILATING ENGINEER in the Naval Construction Department of the Admiralty, Bath—The Ministry of Labour and National Service, Technical and Scientific Register, 26 King Street, London, S.W.1 (July 31).

TECHNICAL OFFICER (with a university degree in science with botany as major subject, or diploma of agricultural college, or equivalent qualifications; experience in cytological techniques essential) in THE DIVISION OF PLANT INDUSTRY, Canberra, to assist the Chief of the Division and other officers engaged in cytological investigations—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3883 (August 9).

CHAIR OF ARCHITECTURAL SCIENCE in the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 11).

DEPUTY PRINCIPAL INSPECTOR (in London) OF MECHANICAL ENGINEERING IN MINES AND QUARRIES, an INSPECTOR (in London) OF MECHANICAL ENGINEERING IN MINES AND QUARRIES, and INSPECTORS (5, in the Provinces) OF MINES AND QUARRIES—The Civil Service Commission, Scientific Branch, 7th Floor, Trinidad House, Old Burlington Street, London, W.1, quoting S.4153/52 (August 13).

CHAIR OF MATHEMATICS in University College, Dundee—The Secretary, The University, St. Andrews (August 15).

GEOPHYSICAL PROSPECTING OFFICER (with a degree in geology and preferably with training or experience in geophysical prospecting methods) IN THE IRRIGATION DEPARTMENT, Southern Rhodesia—The Secretary, Rhodesia House, 429 Strand, London, W.C.2 (August 15).

LECTURER IN PSYCHOLOGY at Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 15).

LECTURER IN ZOOLOGY at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 15).

SENIOR LECTURER IN PHILOSOPHY at the University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 15).

LECTURER IN AGRICULTURAL ENGINEERING at Canterbury Agricultural College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 16).

CHAIR OF BOTANY in the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 30).

LECTURER (Chief Lecturer or Senior Lecturer grade) IN VETERINARY PATHOLOGY at the University of Queensland—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 31).

EDWARD A. DEEDS SENIOR FELLOWSHIP for research in physical science, viz., engineering, metallurgy, chemistry, physics, mathematical physics, or any cognate subject—The Secretary, University College, Dundee (September 1).

CHAIR OF APPLIED MATHEMATICS—The Registrar, University College, Exeter.

DEMONSTRATOR IN THE DEPARTMENT OF ENGINEERING—The Secretary and Registrar, The University, Southampton.

LECTURER and an ASSISTANT LECTURER IN CHEMISTRY—The Secretary, Royal Technical College, Glasgow.

MECHANICAL ENGINEER (Road Plant) IN THE PUBLIC WORKS DEPARTMENT, Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, quoting 'M/E Roads 1866'.

PHYSICIST (with a university degree in physics, or equivalent qualification, and an interest in experimental work on plant in actual operation) for research in Sheffield on methods of measurement and control of metallurgical furnaces—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

PRINCIPAL RESEARCH CHEMIST in the Division of Atomic Energy (Production), Windscale Works, Sellafield, to lead a section engaged on applied research work on a wide range of problems associated with the development of atomic energy (mainly in the field of inorganic and physical chemistry)—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 347.

RESEARCH FELLOWSHIP IN MECHANICAL ENGINEERING—The Registrar, The University, Nottingham.

TECHNICAL ASSISTANT IN THE FUEL SECTION of the Plant Engineering Division in London; the work initially will be largely in connexion with the utilization, instrumentation, and design of furnaces, and with operational studies involving the heating and cooling of steel ingots—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting 'Fuel'.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Royal Commission on University Education in Dundee, 1951–52. Report. (Cmd. 8514.) Pp. 75. (London: H.M. Stationery Office, 1952.) 2*s.* 6*d.* net. [53

British Electrical and Allied Manufacturers' Association. Forty-first Annual Report, 1951–52. Pp. ii+58. (London: British Electrical and Allied Manufacturers' Association, 1952.) [53

Peace and the United Nations. By Dr. Ralph J. Bunche. (Tenth Montague Burton Lecture on International Relations.) Pp. 14. (Leeds: The University, 1952.) 6*d.* [53

Lundy Field Society. Fifth Annual Report, 1951. Pp. 42+2 plates. (Exeter: L. A. Harvey, Secretary, University College, 1952.) 2*s.* 6*d.* [53

The Scientific Education of Physicists. Pp. 32. (London: Institute of Physics, 1952.) 2*s.* [63

Guide to the Use of Aluminium in Public Service Vehicles. (Publication AB.7.)• Pp. 28. (London: Aluminium Development Association, 1952.) 2*s.* 6*d.* [65

Other Countries

Study on Assistance to Indigent Aliens. Pp. iv+81. (New York: United Nations; London: H.M. Stationery Office, 1951.) 50 cents; 3*s.* 9*d.* [65

Stanford Research Institute. Annual Report, 1951. Pp. 48. (Stanford, Calif.: Stanford Research Institute, 1952.) [65

Annual Departmental Report by the Director of Agriculture, Fisheries and Forestry for the Financial Year 1950–1. Pp. iv+72. (Hong Kong: Government Printer, 1952.) [65

Canada: Department of Resources and Development, National Parks Branch. National Museum of Canada, Bulletin No. 125 (Biological Series No. 43): Birds of the West James Bay and Southern Hudson Bay Coasts. By T. H. Manning. Pp. iii+114 (7 plates). (Ottawa: Queen's Printer, 1952.) 25 cents. [65

Stanford University Publications: University Series. Medical Sciences, Vol. 5, No. 1: Companionship of Water and Electrolytes in the Organization of Body Fluids. By James L. Gamble. (Lane Medical Lectures.) Pp. 90. (Stanford, Calif.: Stanford University Press; (London: Oxford University Press, 1951.) 20*s.* net. [65